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A CORRECTION

A Preliminary Report on the Rate of Insecticide Residue Loss from Treated Plants

G. C. DECKER, C. J. WEINMAN and J. M. BANN

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In making up the pages certain sections of the galleys were transposed and should be adjusted as follows: The section beginning with line 12, col. 1, page 922 to line 2, page 923, inclusive, a total of 29 lines, should be placed at the end of the article immediately following line 2, column 2 on page 927. This was presumably committed by the editor rather than by the printers.

THE VOTE ON CONSOLIDATION

Dr. E. N. Cory, Secretary of the Association, has announced that the ballots submitted by members of the Association on the proposal to consolidate the Association and the Entomological Society of America have been received and counted. The vote was strongly in favor of the consolidation. In favor were 1224 ballots while only 217 voted against the merger. This is well above the required two-thirds majority.

The vote of the Entomological Society of America can not be known yet as the deadline for ballots in the Society was June 1 and the results will not be known until some time later than that.

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Evaluation of Some New Insecticides for Apple Maggot Control[1]

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The efficacy of DDT applications for control of the apple maggot, *Rhagoletis pomonella* Walsh, has been established by experiment and through grower use, but the limitations of the material, which include the ever-present problem of excessive spray residues on harvested fruit, have stimulated interest in other insecticides for this purpose. Evaluations of some of the newer insecticidal chemicals for apple maggot control are reported herein. They were made in the laboratory and the field, employing methods previously described (Dean 1946).

MATERIALS.—The chemicals used in both laboratory and field tests were commercial products formulated for spraying purposes by the manufacturer. In some instances, it was necessary to add a wetting agent to the material, as received, in order to obtain, a suspension that was satisfactory for use in the laboratory spray equipment, and one, CS-647A+CS-645A, received as a dust concentrate, required the addition of a wetter in field tests, also.

The materials used and their composition, as stated by the manufacturer, were as follows:

Aldrin—25-per cent wettable powder.
Benzene hexachloride—a 50-per cent wettable powder, 6 per cent of the active ingredient being the gamma isomer.
Chlordane—A 50-per cent wettable powder.
CS-645A—A 50-per cent wettable powder containing 2-nitro-1, 1-bis (*p*-chlorophenyl) propane.
CS-674A—A 50-per cent wettable powder containing 2-nitro-1, 1-bis (*p*-chlorophenyl) butane.
CS-674A+CS-645A—A 50-per cent dust concentrate containing 2 parts of CS-674A and 1 part of CS-645A without wetting agent.
DDT—A 50-per cent wettable powder.
DFDT—A 25-per cent wettable powder containing difluoro diphenyl trichloroethane.
Dieldrin—A 25-per cent wettable powder.
Ditotyl trichloroethane—A 25-per cent wettable powder containing 2,2-di-*p*-tolyl-1, 1,1-trichloroethane.
A 27-per cent wettable powder containing ethyl *p*-nitrophenyl thionobenzene phosphonate.[2]
Heptachlor—A 25-per cent wettable powder.
Methoxychlor—A 50-per cent wettable powder.
No. 3869—A 25-per cent wettable powder containing S-carbamylmethyl 0,0-dimethyl dithiophosphate.
No. 3901—A 25-per cent wettable powder containing 0,0-dimethyl S-(2-oxo-2 ureidoethyl) dithiophosphate.
Parathion—A 15-per cent wettable powder.
Q-137—A 50-per cent wettable powder containing 1,1-di-(*p*-ethylphenyl)2,2-dichloroethane.
TDE—A 50-per cent wettable powder.
Toxaphene—A 25-per cent wettable powder.

LABORATORY TESTS.—Three types of laboratory tests were made. In the first, the flies were exposed to a dried spray film on a glass plate forming the top of the test cage. The insecticide was applied over a sugar film which supplied food during the 10-day test period. Clean water was also furnished. Approximately fifty flies, collected from orchard emergence cages, were used in each test. Since the insects were in contact with the spray film for brief intervals only, these experiments are referred to as *discontinuous exposure* tests. In the second type, petri dishes were used as cages, both halves of the dish being sprayed with the material under test. Clean food, in the form of sugar solution, was furnished in some cases, but it was found to be unnecessary, since the test period was relatively short, and was omitted in others. Here the flies, 10 in number for each test, were in continuous contact with a sprayed surface, so these are termed *continuous exposure* tests. Petri dishes were also used in the third type of laboratory test. In each of these *controlled exposure* tests, 50 flies were exposed for varying periods in sprayed dishes and then transferred to

[1] Journal Paper No. 848, New York State Agricultural Experiment Station, Geneva, New York (Dec. 22, 1950). This work is part of a cooperative project with the Bureau of Entomology and Plant Quarantine, U.S.D.A.
EIN.

clean cages and supplied with unpoisoned food and water. More ingestion of the test materials took place in the discontinuous exposure tests, since the flies were forced there to feed on a sprayed surface, but a limited amount may also have occurred in the other types of tests since the flies habitually "taste" all surfaces upon which they alight.

A limited number of tests for vapor

Table 1.—Results of laboratory tests on apple maggot adults, 1947–1950.

Material	Exposure										
	Discontinuous				Continuous		Controlled				
		Per Cent Mortality Accumulated in—Days			Hours Required for				Per Cent Mortality Accumulated in—Days		
	Amount 100 Gals.	1	5	10	Complete Knockdown	Complete Mortality	Lbs. per 100 Gals.	Exposure-Minutes	1	5	10
50% Chordane	8 oz.	0	20	24	25–50	25–50	2	0	4	6 (3)[1]	
	1 lb.	4	50	64	9	13–22		5	88	100 (3)	
	2 lbs.	24	100 (2)		73+	73+		10	98	100 (2)	
	4 lbs.	88	100 (2)		5	25–50		15	100		
15% Parathion	8 oz.	70	100 (2)		3	8	1	0	2	2	
	1 lb.	100			3	13–22		5	96	100 (2)	
	2 lbs.	100			2	8		10	100		
	4 lbs.	100			2	7					
15% Parathion	1 oz.	4	36	46							
	2 oz.	42	98	98							
	4 oz.	69	96	100							
	8 oz.	94	100 (2)								
	1 lb.	100									
50% DDT	8 oz.	0	18	22	5	25–50	2	0	2	2	2
	1 lb.	0	6	16	4	25–50		90	90	98	98
	2 lbs.	0	8	32	2	25–50		120	98	98	98
	4 lbs.	10	36	52	3	25–50		180	98	98	98
								210	100		
25% Toxaphene	1 lb.	0	100 (3)		25–50	25–50	4	0	0	2	8
	2 lbs.	0	100 (2)		8	25–50		5	2	4	14
	4 lbs.	14	100 (2)		7	25–50		10	6	10	20
	8 lbs.	56	100 (2)		6	9		15	4	10	19
								30	22	46	46
								60	78	90	90
25% Toxaphene							4	0	2	2	2
								60	84	100 (2)	
								75	100		
50% BHC (6% γ isomer)	8 oz.	0	0	0	73+	73+	3	0	0	4	10
	1 lb.	0	0	0	8	25–50		5	40	54	56
	2 lbs.	0	6	10	4	7		10	94	96	96
	4 lbs.	0	2	2	2	8		15	100		
Check		0	2	4	*None*[2]	*None*[2]					
25% Ditolyl trichloroethane	1 lb.	0	2	4	9–25	26–49	4	0	0	4	8
	2 lbs.	0	4	4	9–25	9–25		5	0	0	2
	4 lbs.	0	2	6	4	9–25		10	0	2	8
	8 lbs.	0	2	5	2	9–25		15	0	4	4
								30	0	10	12
								60	22	41	45
								120	80	94	96
								180	96	98	98
								240	100		
Check		0	6	6							
50% TDE	8 oz.	0	2	2	9–25	26–49	2	0	0	2	2
	1 lb.	0	2	6	9–25	9–25		5	0	4	4
	2 lbs.	0	2	6	9–25	26–49		10	0	0	0
	4 lbs.	10	64	88	6	26–49		15	2	40	40
								30	2	8	10
								60	11	15	17
								120	100		
Check		0	0	2							
50% Methoxychlor	8 oz.	0	2	2	7	78+	2	0	0	4	6
	1 lb.	0	0	2	4	50–78		5	2	4	4
	2 lbs.	0	0	2	2½	26–49		10	0	4	4
	4 lbs.	0	4	6	2	50–78		15	0	2	2
								30	0	2	4
								60	29	37	39
								120	100		
Check		0	2	2	*None*[2]	*None*[2]					

Table 1—*continued.*

Material	Exposure									
	Discontinuous				Continuous		Controlled			
	Amount 100 Gals.	Per Cent Mortality Accumulated in—Days			Hours Required for		Lbs. per 100 Gals.	Exposure—Minutes	Per Cent Mortality Accumulated in—Days	
		1	5	10	Complete Knockdown	Complete Mortality			1	5	10
25% No. 3869	2 oz.				7	10					
	4 oz.				5	10					
	8 oz.				5	7					
	1 lb.				3	7					
25% No. 3901	2 oz.				13–22	13–22					
	4 lbs.				8	11–12					
	8 lbs.				6	11–12					
	1 lb.				6	13–22					
Check					*None*[2]	*None*[2]					
50% CS-645A	8 oz.				1¼	12–23					
	1 lb.				½	24–48					
	2 lbs.				½	12–23					
	4 lbs.				½	24–48					
50% CS-674A	8 oz.				1	12–23					
	1 lb.				½	9–11					
	2 lbs.				½	12–23					
	4 lbs.				½	48+					
Check					*10%*[3]	*10%*[3]					
50% Q-137	8 oz.	22	94	96	5	13–24	2	0	0	2	4
	1 lb.	36	100 (4)		4	12		5	8	12	12
	2 lbs.	60	100 (3)		4	13–24		10	29	54	54
	4 lbs.	74	100		3	13–24		15	39	73	73
								30	94	96	96
								60	96	100 (4)	
50% CS-674A+CS-645A	8 oz.	49	98	100 (6)	4	13–24	2	5	27	43	43
	1 lb.	34	96	100 (9)	3	13–24		10	56	72	72
	2 lbs.	83	100 (3)		1½	13–24		15	20	64	64
	4 lbs.	68	100 (3)		2	13–24		30	94	96	96
								60	100		
Check		4	12	12							
25% Dieldrin	1 lb.	73	100		4	10	4	0	0	4	4
	2 lbs.	100			4	11–12		5	96	100 (2)	
	4 lbs.	100			3	10		10	100		
	8 lbs.	100			2	13–24					
25% DFDT	1 lb.	0	4	4	8	13–24	4	5	2	8	14
	2 lbs.	2	14	14	3	25–48		10	2	2	6
	4 lbs.	18	26	28	1	11–12		15	22	24	28
	8 lbs.	50	68	72	1	13–24		30	50	64	66
								60	92	94	94
25% Heptachlor	1 lb.	86	100 (2)		3	13–24	4	5	100		
	2 lbs.	100			3	8					
	4 lbs.	100			3	9–10					
	8 lbs.	100			2	13–24					
Check		0	0	2	*None*[2]	*20%*[3]					
25% Aldrin	1 lb.	30	100		7	13–24	4	0	0	4	74
	2 lbs.	56	100 (3)		3	25–48		5	96	100 (2)	
	4 lbs.	71	100 (2)		3	25–48		10	100		
	8 lbs.	100			3	13–24					
27% EPN	2 oz.	21	98	100 (8)	10	25–48	0.5	0	2	6	96
	4 oz.	46	96	100 (7)	7	25–48		5	6	24	100 (9)
	8 oz.	83	100 (3)		3	25–48		10	33	51	100 (8)
	1 lb.	82	100 (4)		4	25–48		15	44	56	100 (9)
								30	100		
Check		2	4	80	*None*[2]	*None*[2]					

[1] Figures in parentheses represent the actual day on which the indicated mortality level was reached.
[2] No knockdown or mortality during the test period.
[3] In 48 hours.

toxicity were made by exposing flies in a clean half-petri dish above a sprayed half-dish, the two being separated by a cheesecloth barrier. The exposure period used was 90 minutes, after which the flies were confined in clean rearing cages for ten days' observation.

Discontinuous Exposure Tests.—In this

type of test, DDT shows limited toxicity to the apple maggot fly (Dean (1946). As seen in table 1, similar results were obtained. Benzene hexachloride, ditolyl trichloroethane, TDE and methoxychlor, in general, appeared less toxic than DDT, while DFDT is slightly more toxic. Chlordane, at 0.5 and 1.0 pound per 100 gallons, did not give complete kill within the 10-day test period, but, at 2 and 4 pounds per 100 gallons, mortality was complete in 2 days. Q-137 gave a complete kill in from 3 to 5 days, except at a dosage of 0.5 pound in 100 gallons, where the mortality reached 96 per cent in 10 days. Parathion, at 1 and 2 ounces per 100 gallons, did not cause complete mortality, but at all higher dosages, all flies were killed within two days at the one-half pound per 100 gallon dosage and in the first 24-hours at one pound or more per 100 gallons. Toxaphene required 2 to 3 days, and heptachlor 1 to 2 days to cause complete mortality. Aldrin and dieldrin were effective in from 1 to 5 days, the latter being somewhat faster in its toxic action. EPN killed all flies in 3 to 8 days, and CS-674A+CS-645A in 3 to 9 days.

Continuous Exposure Tests.—The observation period in this series of tests was 48 to 73 hours (Table 1). For the first hour observations were made at 15-minute intervals, then at half-hour intervals for the next hour and one-half, followed by hourly observations until the eighth to tenth hour and again at the twelfth, twenty-fourth, forty-eighth and seventy-third hours. In the 1948 series, no observations were made between the eighth and twenty-fourth hours.

In these tests the rate of knockdown is of more significance than the time of actual mortality, which is often difficult to determine. In very few instances was there any evidence of recovery of flies which had been knocked down so that, for all practical purposes, knockdown may be used as the criterion for control.

Only two treatments failed to give complete knockdown within 48 hours. Chlordane, at 2 pounds per 100 gallons gave results inconsistent with those shown by other concentrations of the material so that this test may be considered aberrant, while benzene hexachloride, at 8 ounces per 100 gallons, may have been too low a concentration to induce a total knockdown. Toxaphene, benzene hexachloride, ditolyl trichloroethane, TDE, No. 3901 and EPN were all somewhat slower than DDT in rate of knockdown. Methoxychlor, No. 3869, Q-137, CS-645A+CS-674A, dieldrin, heptachlor and aldrin were similar to DDT, while parathion and DFDT were faster. The nitroparaffins, CS-645A and CS-674A caused the most rapid knockdown of any of the materials tested. It is interesting to note that only one of these tests gave a complete kill in less than 24 hours, four of them required 24 hours and two required 48 hours to cause complete mortality, while one yielded no more than 90 per cent mortality during the test period.

Controlled Exposure Tests.—Only one concentration of each material was tested in this series. Of the chlorinated hydrocarbon compounds examined, 50 per cent materials were used at the rate of two pounds and 25 per cent materials at the rate of four pounds per 100 gallons. Parathion was tested at one pound and EPN at one-half pound per 100 gallons. Exposure periods ranged from five to 240 minutes in length (Table 1).

At the concentrations tested, heptachlor gave the most rapid kill, five minutes exposure being sufficient to kill all flies within the first 24 hours. Parathion, dieldrin and aldrin were next, the 5-minute exposure causing complete mortality in two days while a 10-minute exposure accomplished the same result in 1 day. A 15-minute exposure to chlordane resulted in total mortality within 24 hours, a 10-minute exposure was equally effective in 2 days while a 5-minute exposure required 3 days. A 15-minute exposure to benzene hexachloride also gave complete kill in 1 day, but neither the 5-minute nor the 10-minute exposure periods were sufficient to cause complete mortality during the 10-day test period. EPN was completely effective in 1 day after a 30-minute exposure, but shorter exposure periods required 8 to 9 days to produce complete kill. Although a 60-minute exposure to CS-674A+CS-645A caused total mortality in 24 hours, none of the shorter exposures produced this result within the test period. Toxaphene gave a complete kill in 1 day after an exposure period of 75 minutes, and in 2 days after a 60-minute exposure. A 60-minute exposure to Q-137 resulted in complete

mortality in 4 days, none of the shorter exposure periods being this effective in 10 days. Methoxychlor and TDE each required more than a 60-minute exposure to give a complete kill, this being accomplished in 1 day after a 120-minute exposure. It is probable that DFDT is about as effective but it was not tested at an exposure period greater than 60 minutes. It has been shown (Dean 1946) that DDT requires an exposure period in excess of 60 minutes in order to produce a total kill. This result was finally accomplished within 1 day by an exposure of 210 minutes. Shorter exposures failed to cause complete mortality within the 10-day test period although the 98 per cent mortality level was reached with a 90-minute exposure period. Ditoyl trichloroethane was the only material tested which apparently required a longer exposure period than DDT. After 240 minutes' exposure, complete mortality followed in 1 day. However, the material was not tested at exposure periods between 180 and 240 minutes.

Vapor Toxicity.—Using the concentrations employed in the controlled exposure series, dried spray films of chlordane, parathion, toxaphene, benzene hexachloride and DDT were tested for vapor toxicity. Chlordane alone showed a pronounced effect, the mortality level reaching 48 per cent in 5 days and 50 per cent in 10 days. Mortality reached a maximum of 15.7 per cent in 4 days in the benzene hexachloride treatment, while parathion caused 4 per cent maximum kill in 4 days. Neither toxaphene nor DDT exhibited any vapor toxicity.

Field Tests.—Laboratory tests serve to demonstrate whether or not an insecticide is toxic to the apple maggot fly, and indicate the relative speed with which it causes death but no satisfactory laboratory method has yet been developed to measure the residual effectiveness of sprays as well as is done by field testing. The procedure used was the same as that previously described (Dean 1946). More or less isolated blocks of infested trees were sprayed with the material under test, using standard orchard sprayers, and treating all trees in the block as well as adjoining hedgerows, woods or other high vegetation. Single-nozzle guns were used from the ground, except in the case of small trees, which were sprayed from the rig. Control data were taken by examining for egg punctures all the fruit, both picked and drops, from several trees. Questionable fruits were cut to determine the presence or absence of internal signs of infestation. The percentage of infested fruit found was compared to the amount occurring in the preceding season. The materials used and results obtained are shown in table 2.

The same orchard was used for tests 1, 2, 3 and 6. In the 1947 season, it received four applications of 50 per cent chlordane at the rate of 2 pounds per 100 gallons. The amount of fruit infestation by apple maggot increased from 30 per cent to 47.7 per cent. The following year, three applications of toxaphene, at the rate of 1 pound of actual toxaphene in 100 gallons of spray, permitted an increase to 76.6 per cent infested fruit. The 1949 program consisted of four applications of 50 per cent TDE at 2 pounds in 100 gallons. Fruit infestation was reduced to 14.4 per cent. In 1950, five applications of 60 per cent CS-674A+CS-645A at 2 pounds per 100 gallons, caused a further reduction to 4.9 per cent. This treatment caused russetting and spotting of the fruit, the former being most severe on the variety Red Delicious, while the latter was most conspicuous on McIntosh.

The results in this orchard indicate that residual action from chlordane is rather brief, probably less than that obtained with DDT sprays, while toxaphene is, at best, no more persistent than DDT. Control appeared good and until mid-August but deteriorated rapidly from then until harvest. TDE, although it was not outstandingly toxic in the laboratory, stood up well under orchard conditions. Its residual action seems to persist for the same length of time as that of DDT, *i.e.*, about 10 days. CS-645A+CS-674A was effective, as used, but there is evidence that it was losing residual toxicity in the difference in degree of infestation between varieties. The McIntosh apples, which were harvested a month before the Red Delicious, averaged considerably under 1 per cent infested fruit as compared to 14.2 per cent for the Delicious. The injury caused by this material was sufficient to eliminate it from further consideration.

Tests 4 and 9 were also conducted in

Table 2.—Results of orchard tests for apple maggot control, 1947–1950.

Test No.	Materials in 100 Gallons of Spray	Date of Application	Fruit Examined		Per Cent Infested	Residue Gr./Lb.
			Variety	Number		
1	50% Chlordane 2 lbs.	June 23,	McIntosh	683	21.81	0.6[1]
		July 5,	McIntosh	1,151	16.59	0.7
		July 16 and	McIntosh	794	33.37	0.4
		Aug. 4, 1947	McIntosh	507	72.39	
			R. Delicious	382	94.50	
			Total	3,517		
			Average		47.73	0.57
			1946 Average		30.15	
2	40% Toxaphene 2.5 lbs.	June 30, and	McIntosh	3,981	66.34	
	Wettable Sulfur Paste 5 to 6 lbs.	July 9, 1948	McIntosh	694	26.66	
			McIntosh	1,757	73.88	
	25% Toxaphene 4 lbs.	July 20, 1948	R. Delicious	392	98.98	
			R. Delicious	1,323	95.09	
			R. Delicious	435	99.08	
			Total	8,582		
			Average		76.67	
			1947 Average		47.73	
3	50% TDE 2 lbs.	June 27,	McIntosh (14 trees)			
		July 8,	Total	8,594		
		July 20 and	Average		14.43	
		Aug. 4, 1949	1948 Average		76.67	
4	15% Parathion 2 lbs.	June 27,	Baldwin	2,002	96.15	
		July 7,	Baldwin	1,711	90.65	
		July 18 and	Jonathan	2,140	83.32	
		July 28, 1949	Jonathan	2,799	91.28	
			Total	8,652		
			Average		90.35	
			1948 Average (estimated)		75.00	
5	Lead Arsenate 3 lbs.	June 28 and	Wealthy	4,883	1.72	Pb 0.066[2]
	15% Parathion 1 lb.	July 19, 1949	Wealthy	5,418	2.31	As_2O_3 0.033
	Wettable Sulfur 4 lbs.		Wealthy	3,232	0.99	
			McIntosh	1,945	3.29	
			McIntosh	1,579	1.14	
			R.I. Greening	3,386	2.10	
			Total	20,443		
			Average		1.93	
			1948 Average		22.64	
6	50% CS-674A+CS-645 A 2 lbs.	June 27,	McIntosh	1,973	0.30	0.029[3]
	Wetting Agent[3] 75 cc.	July 7,	McIntosh	2,339	0.17	
	Wettable Sulfur 4–5 lbs.[4]	July 17,	McIntosh	5,011	0.22	
		July 27 and	McIntosh	2,511	0.32	
		Aug. 8, 1950	R. Delicious	2,065	7.89	
			R. Delicious	4,353	20.58	
			Total	18,252		
			Average		4.91	
			1949 Average		14.43	
7	50% Methoxychlor 2 lbs.	June 26,	McIntosh (60 trees)	1,119	7.33	0.0028[3]
	Wettable Sulfur 4–5 lbs.[4]	July 6,	Cortland (34 trees)	6,966	3.90	0.0034
		July 17,	Total	8,085		
		July 27 and	Average		5.61	0.0031
		Aug. 8, 1950	1949 Average (estimated)		95.00	
8	25% Dieldrin 2 lbs.	June 26,	McIntosh			0.0[6]
	Wettable Sulfur 4–5 lbs.[4]	July 19 and	Macoun (17 trees)	488	99.59	
		Aug. 11, 1950	Cortland (9 trees)	503	99.60	
			G. Delicious (8 trees)	1,612	98.88	
			Total	2,603		
			Average		99.15	
			1949 Average (estimated)		98.00	
9	Lead Arsenate 3 lbs.	June 26,	Baldwin	1,694	99.94	Pb 0.112[2]
	15% Parathion 1 lb.	July 19 and	Baldwin	4,508	99.98	
	Wettable Sulfur 4–5 lbs.[4]	Aug. 9, 1950	Jonathan	2,529	99.80	As_2O_3 0.055
			Jonathan	3,499	99.97	Parathion 0.0002
			Total	12,230		
			Average		99.92	
			1949 Average		90.35	

[1] Determined by Division of Insecticide Investigations, Bureau of Ent. & Plant Quar., U.S.D.A.
[2] Determined by A. W. Avens, Div. Food Sci. & Technol., N.Y. St. Agric. Exper. Sta.
[3] Either *Tween 85* or *Triton B-1956*.
[4] Omitted from last application.
[5] Determined by Commercial Solvents Corp. Research Dep't.
[6] Determined by Julius Hyman & Co. Technical Service Laboratory.

the same block. In 1949, four applications of parathion permitted an increase in fruit injury from approximately 75 per cent to 90.3 per cent. The 1950 schedule, employing a combination of lead arsenate and parathion in three applications was no more successful, the injury increasing further to 99.9 per cent. Parathion, under field conditions, does not appear to be effective in controlling the apple maggot fly for more than a few days. The addition of lead arsenate, which is one of the more persistent insecticides used against apple maggot, failed to increase the control under 1950 conditions. In 1949, in test 5, this combination gave good results with two applications.

Methoxychlor, at the rate of 1 pound of the actual material in 100 gallons of spray, gave excellent control in test 7, where it was applied five times. This orchard, which was severely infested in 1949, had a small crop in 1950, so that the infestation was concentrated on a relatively small number of apples. Despite this, the reduction in infested fruit was pronounced. In the laboratory, methoxychlor was one of the slower-acting materials but, under field conditions, this is apparently offset by a longer period of residual effectiveness.

Because of its apparent toxicity under laboratory conditions and its supposed persistence, dieldrin was selected for a limited trial in test 8. It is obvious that toxicity did not persist for as long as was anticipated. The period of residual effectiveness of dieldrin is not known but it is not markedly greater than that of DDT, if as long.

SUMMARY.—In laboratory tests, parathion, dieldrin and heptachlor were outstanding in their toxicity to and speed of killing of apple maggot flies. Toxaphene, aldrin, EPN, CS-645A+CS-674A and Q-137 were also very toxic to the flies but slower in action. Chlordane was less toxic, except at higher concentrations, and required a relatively long time to become effective, although it appears that short periods of exposure are sufficient to cause death eventually. Chlordane also exhibited definite vapor toxicity. DFDT was more toxic than DDT and also more rapid in its lethal action. In discontinuous exposure tests, benzene hexachloride, ditolyl trichloroethane, TDE and methoxychlor appeared to be less toxic than DDT and little, if any, faster in causing knockdown in continuous exposure tests. The most rapid knockdown of flies was caused by the nitroparaffins, CS-645A and CS-674A. With the exception of ditolyl trichloroethane, all caused a more rapid kill than DDT in controlled exposure tests.

Under field conditions, chlordane, toxaphene, dieldrin and parathion failed to give adequate protection. A combination of lead arsenate and parathion was effective in 1949 but failed completely in 1950. CS-674A+CS-645A gave good control in a moderate infestation but caused fruit injury, and TDE and methoxychlor were successful in reducing the amount of fruit injured in initially high infestations. Lack of residual toxicity appears to be the reason for the failure of some insecticides, which are highly effective in the laboratory, to maintain control in the orchard.

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LATIN-AMERICAN PLANT PROTECTION MEETING IN MEXICO

The first Latin-American plant protection meeting took place in Mexico, D. F. from September 25 to October 6, 1950. It was held under the auspices of the Rockefeller Foundation and the Mexican Department of Agriculture. Delegates from 13 Latin-American countries and the United States participated in the meetings. During the first four days delegates presented papers reporting research on pests and diseases of cereals, forage and field crops, fruits, and special crops such as sugar cane, coffee cacao, bananas, and others. Following the presentation of papers the Foundation conducted field trips to the experiment stations located in the valley of Mexico and in the Bajio, the corn belt of Mexico, to show the delegates investigations in progress on the pests and diseases of corn, wheat, beans, tomatoes and potatoes. The Division of Fruit Fly Investigations of the U.S.D.A. and the Mexican government arranged a trip to Valles, San Luis Potosi to demonstrate the black fly investigations and control work.

Tabanid Control on Dairy and Beef Cattle with Synergized Pyrethrins

W. N. Bruce and G. C. Decker[1]

In preliminary experiments conducted during the summer of 1947, activated pyrethrins were found superior to other materials tested in combating *Tabanus sulcifrons* Macquart in southern Illinois.

In 1948 repeated tests showed that spraying cattle with an emulsion containing 0.125 per cent pyrethrins and 2.5 per cent piperonyl butoxide protected them from tabanids usually for from 3 to 5 days, but seldom longer. Since frequent treatments on beef animals appeared impractical, most of the 1949 experiments were restricted to dairy animals that could be easily and conveniently treated at least twice weekly.

The 1949 experiments were concerned with the economics of securing a maximum amount of protection with a minimum of expense and effort. Twelve herds were divided into six groups of two herds each. Three groups were sprayed with ordinary hand sprayers using the undiluted pyrenone concentrate[2]: two herds of these groups were sprayed twice daily (1 to 2 ml. per animal) two were sprayed once daily (2 to 5 ml. per animal), and two were sprayed twice weekly (22 to 39 ml. per animal). The other three groups were sprayed with a knapsack compressed air sprayer using the same concentrate diluted 1 part to 9 parts of water; two herds of these groups were sprayed three times a week (0.25 pt. per animal), two were sprayed twice weekly (0.25 to 0.5 pt. per animal), and two were sprayed once weekly (0.8 to 1.5 pts. per animal).

The data obtained on the effectiveness of these applications with different kinds of sprayers and varied amounts of material are summarized in table 1. The great saving of materials in the case of applications made at frequent intervals is of particular interest. Control was best and the least amount of material was consumed when light applications were made twice daily. The commercially available oil repellents containing 0.25 per cent piperonyl butoxide and 0.025 per cent pyrethrins did not effectively control tabanids when used at daily dosages of 1 or 2 ounces of spray per animal.

1950 Experiments on Dairy Cattle.—Before the beginning of this summer's experiments a questionnaire was mailed to all prospective cooperators in the horse fly infested areas of southern Illinois. Interesting estimates of the losses caused by the horse fly were obtained. The farmers' estimates on milk production losses ranged from 25 per cent to 40 per cent. One farmer made the statement that during a severe horse fly season his milk cows became nearly dry and were unable to return to their former production levels even after the horse flies disappeared. Howard (1916) indicated that horse flies reduced milk production 66 per cent in 2 weeks and nearly 100 per cent in 3 weeks of sustained attack. Certainly besides the direct loss of large amounts of blood, animals suffer from the loss of energy which they dissipate in attempts to evade their voracious enemies. A combination of blood loss, energy loss, and loss of grazing time contributes to reductions in milk.

To measure the production losses suffered by milk cows, an experiment was conducted with 25 herds (293 head of cattle) in southern Illinois in the summer of 1950. Milk production records for all herds were kept throughout the experiment and they were summarized for four production periods of 30 days each, as follows: I. May pre-fly season; II. June pre-treatment; III. July treatment; and IV. August largely post fly season. Twelve herds were treated at least twice weekly with *Pyrenone* emulsion sprays containing not less than 1.0 per cent piperonyl butoxide and 0.1 per cent pyrethrins. The average dosage needed to secure excellent tabanid control was 10 to 15 ounces of emulsion (1 to 1.5 ounces *Pyrenone*) per cow per week. Treatments were not started until tabanids were present in considerable numbers on all herds, which was at the end of the second

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[2] *T-143.*

Table 1.—**The effect of various spray applications of pyrenone T-143 upon horse fly control in southern Illinois from June 1 to July 30, 1949.**

APPLICATION	ML. PYRENONE T-143[1] PER COW PER WEEK	AVERAGE REDUCTION OF TABANIDS
Hand sprayer:		
2×daily	12.0–24.0 ml.	98.2%
1×daily	15.0–34.0 ml.	95.0%
2×weekly	45.0–78.0 ml.	91.7%
Compressed air sprayer:		
3×weekly	25.2–63.0 ml.	93.0%
2×weekly	27.0–66.0 ml.	90.8%
1×weekly	39.6–75.0 ml.	85.3%

[1] Pyrenone T-143 contains 10% piperonyl butoxide and 1% pyrethrins.

30-day test period, June 29, 1950. Previous to treatments with *Pyrenone* sprays, seven of the herds had been treated with DDT, three with methoxychlor, and two with ordinary fly repellents. Of the 13 check herds, six were treated with DDT, five with methoxychlor and two with oil repellent sprays. Both DDT and methoxychlor were used primarily to eliminate horn flies. The stable fly population was so low in southern Illinois that no satisfactory stable fly counts were accumulated. Since horn flies were nearly eliminated and stable flies were at an unusually low level, these flies were not considered important in this experiment. Even the horse fly season was rather unusual, inasmuch as the tabanids were prevalent from early June until the middle of August, which was approximately 2 weeks longer than a normal season. The numbers of animal fly counts made and the average number of *Tabanus sulcifrons* per animal for periods I, II, III, IV are shown in tables 2 and 6.

Although these amassed animal counts seemed quite adequate, too few daily and hourly counts were made to determine the day-to-day and hour-to-hour fluctuations in the number of tabanids frequenting the cattle. Until these counts are made, a true estimate of tabanid populations and damage cannot be given. The data presented in figures 1, 2, and 3 are indicative of the relative population changes. Very few fly counts were made when tabanids were most numerous on the cattle. In reality each mean consists of a number of fly counts made throughout the day even when the tabanids were not actively attacking the cattle. Fly counts were made at least once a week on each herd (weather permitting) with the greatest number of animal fly counts being made during the outbreak and treatment periods. In confirmation

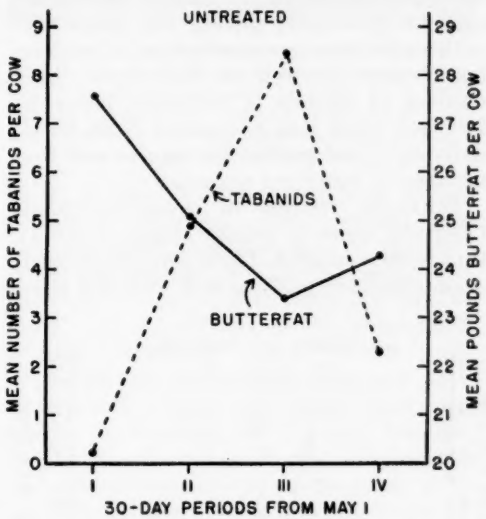

FIG. 1.—Mean number of tabanids and mean pounds butterfat produced per animal during four successive 30-day periods for 13 untreated dairy herds.

Table 2.—**Number of animal counts and average number tabanids per animal per 30-day period. Treatment started June 29, 1950.**

	BEFORE TREATMENT				DURING TREATMENT			
	Period I—May		Period II—June		Period III—July		Period IV—August	
	Number of Animal Counts	Average Number Tabanids per Animal	Number of Animal Counts	Average Number Tabanids per Animal	Number of Animal Counts	Average Number Tabanids per Animal	Number of Animal Counts	Average Number Tabanids per Animal
Check	130	0.23	200	4.90	290	8.50	280	2.27
Treated	120	0.20	250	7.30	300	0.38	390	0.11

Table 3.—The effect of temperature upon the number of *Tabanus sulcifrons* occurring on cattle at the Dixon Springs Experiment Station, 1949.

Temp. F.	75°	80°	83°	85°	87°	89°	91°	95°
Average number tabanids	0.5	4.6	8.3	26.8	47.0	55.7	57.6	58.1

Note: Wind velocity less than 5 m.p.h.

of these fly counts, the cooperators made observations during the post-milking periods on the maximum numbers of tabanids occurring on the more susceptible animals. These data, not presented in this paper, revealed an astounding prevalence of horse flies on untreated milk cows just before milking time.

Butterfat data were used in preference to milk production figures, since it was felt that reduction in milk flow might be accompanied by an increase of butterfat content. However, during the horse fly outbreaks there was a reduction in butterfat content as well as milk flow. The number of pounds of butterfat per cow for each herd was computed from total daily butterfat production figures and the number of lactating animals.

Butterfat records of seven purebred Guernsey cows in similar stages of lactation were compiled. These animals grazed upon excellent pasture and were fed adequate supplementary rations throughout the experiment.

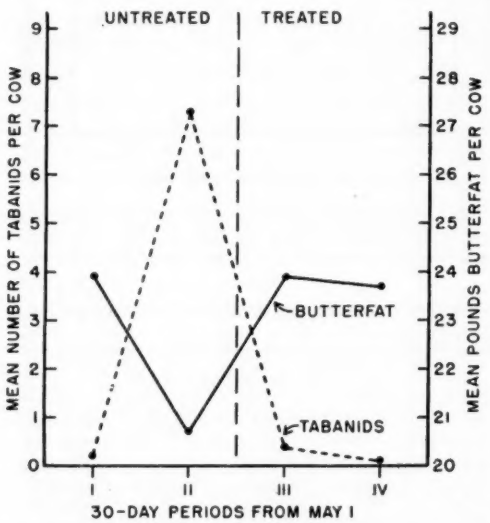

FIG. 2.—Mean number of tabanids and mean pounds butterfat produced per animal during four successive 30-day periods for 12 treated dairy herds. Treatments started the last day of the second 30-day period.

Table 4.—Butterfat production differences for untreated herds given as the deviation in pounds butterfat per animal between successive 30-day test periods.

Herd Number	Deviation between Successive 30-Day Periods		
	I–II	II–III	III–IV
1	−4.1	−1.8	−0.2
2	−4.9	+2.7	−3.0
3	−0.1	+2.8	−1.4
4	−5.2	−3.6	−0.4
5	−2.7	−2.8	+4.1
6	−5.6	−1.1	+3.4
7	−3.3	−1.6	−2.8
8	0.0	−0.1	−1.3
9	−0.3	−0.3	+2.4
10	−4.7	−5.3	+0.2
11	−1.5	−1.6	−2.0
12	−2.9	−2.1	+2.0
13	+2.9	−6.8	+0.2
Mean	−2.5	−1.7	+ .09

Note: There is no statistically significant change among the means of the butterfat production trends.

Heterogeneity in herd production data resulting from pasture differences was minimized by the exceptionally good growing season with its abundant rainfall. Consequently, butterfat yields were obtained for satisfactory statistical analysis.

Table 3 is included here to show the influence of temperatures upon horse fly densities. From this it was concluded that making fly counts on animals when the air temperature is below 85° F. is of little value and should be avoided in accumulating fly counts.

RESULTS.—Tables 4 and 5 present values which represent the loss or gain in butterfat production (expressed as pounds butterfat per cow) between two successive 30-day test periods. Analysis of these data, table 5, shows that a significant change in the butterfat production occurs at the time of treatment. Furthermore, as shown in table 4, there is no significant change between periods for the untreated herds. The strong inverse correlation of the changes in pounds of butter fat and changes in the tabanid counts between the second and third test periods for all 25 herds was found to be −.747 with −.4869 required for significance at the 1 per cent level. Figures 1 and 2 show plainly the high degree of inverse correlation between tabanid densities and butter-

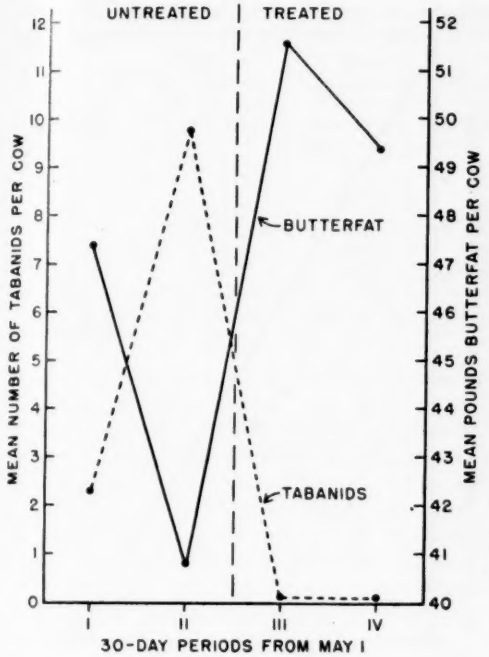

FIG. 3.—Mean number of tabanids and mean pounds butterfat produced per animal during four successive 30-day periods for seven animals in similar stages of lactation. Treatments started the last day of the second 30-day period.

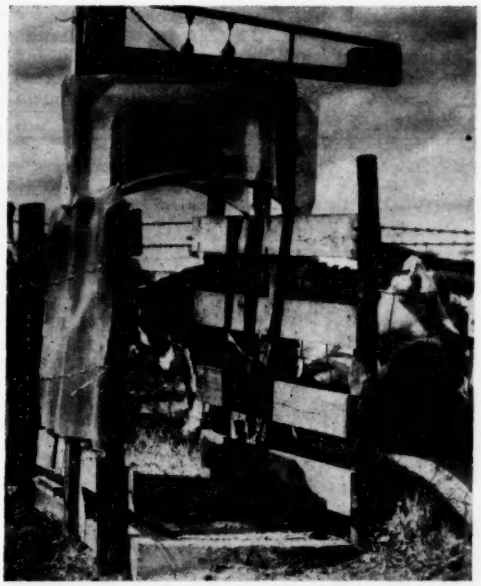

FIG. 4.—Automatic micro-spray applicator as used in a pasture at the Dixon Springs Experiment Station. The animal depresses a treadle as it walks through the chute and the treadle in turn actuates two very small hydraulic sprayers which treat the back and sides of the animal.

fat yields. The indicated increment in butterfat production resulting from the treatment of 12 herds was calculated to be 13.0 to 14.8 per cent.

Tables 6 and 7 present data showing the very significant change in the butterfat production of individual animals which occurred at the time of treatment. The particular herd represented in these tables was subjected to an unusual outbreak principally of two species of small tabanids, *Tabanus lineola* Fabricius and *T. quinquevittatus* Wiedemann, which developed in May and lasted through much of June or until the *Tabanus sulcifrons* became abundant. Actually these flies were so numerous in late May and early June that it was not possible to make satisfactory fly counts. Needless to say, this early attack by the small tabanids, followed by an attack of the large *Tabanus sulcifrons*, greatly depressed the butterfat production. It will be noticed, tables 6 and 7, that the first treatment period was associated with more than a 20 per cent increase in butterfat production. The high level of butterfat yield of the second treatment period reflects a sustained recovery period from the combined tabanid attacks of May and June. The changes of butterfat production correlated closely with changes in the horse fly population as is graphically shown in figure 3.

Preliminary tests with allethrins activated with various synergists were successful in warding off tabanid attacks; the data collected were not adequate to indicate a superiority of one spray over another. Allethrins without an activator gave 2 to 3 days of protection from tabanids.

1950 EXPERIMENTS ON BEEF CATTLE.—Practical control of tabanids on range beef animals was first obtained during the summer of 1950 with the use of an automatic micro-spray applicator. The unit consisted of a homemade chute with a treadle in the floor which operated two small overhead hydraulic pumps connected to a 1-gallon can filled with the spray concentrate, figure 4. This apparatus sprayed a minute amount (0.6–1 ml.) of spray concentrate on the animals as they walked through a chute on their way to drink or lick salt. Thus, the animals during their daily routine made one or two

Table 5.—Butterfat production differences for treated herds given as the deviation in pounds butterfat per animal between successive 30-day test periods. Treatment started the end of period II, June 29, and continued through the fourth period, which ended August 28, 1950.

Herd Number	Deviation between Successive 30-Day Periods		
	I–II	II–III	III–IV
1	−6.2	− 6.4	+ 6.4
2	−6.9	− 0.5	− 5.0
3	−3.0	+ 6.5	− 5.4
4	−3.5	+ 3.7	+ 6.6
5	−2.9	+ 3.8	+ 2.8
6	−1.5	+ 1.6	+ 2.3
7	−1.8	+10.5	−12.2
8	−3.6	+ 2.2	+ 1.7
9	−2.4	+ 0.8	+ 2.1
10	−4.8	+ 1.7	− 3.5
11	−2.7	+ 2.1	+ 1.5
12	+0.7	− 0.7	+ 1.4
Mean	−3.22	+3.2	−0.34

Note: Mean difference for significance; 5% level 3.6; 1% level 4.9. Total differences of trends are 6.42 and 3.56 respectively. The first change in trend occurring at the time of treatment is highly significant.

round trips through the chute. This sprayer was used throughout the horse fly outbreak period in pasture number 1 of experiment 10 at the Dixon Springs Experiment Station of the University of Illinois. In this setup 10 head of comparable animals were pastured in each of 6 adjacent 10-acre improved legume and grass pastures. Table 8 contains data that indicate the high degree of tabanid control and also the beneficial effects upon weight gains of the beef cattle in pasture number 1. It appears that in 38 days the protected animals in pasture number 1 gained 20 to 30 pounds per animal more than those in the other pastures. There was good correlation

Table 6.—Number of animal counts, mean pounds butterfat, and mean number of tabanids per 30-day period for animals in continuous lactation. Treatment started at the end of period II, June 29, 1950.

	30-Day Periods			
	I	II	III	IV
	Before treatment		During treatment	
Number of animal counts	10	20	30	30
Mean number *Tabanus sulcifrons* per animal	2.3	9.8	.075	0.1
Tabanus lineola and *T. quinquevittatus*	very numerous	few	none	none
Pounds butterfat per animal	45.37	40.9	51.83	49.30

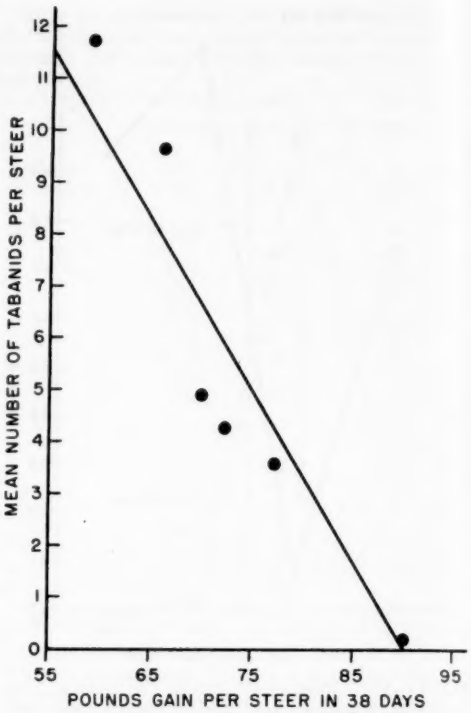

Fig. 5.—Regression line drawn to show the high degree of inverse correlation between mean number of tabanids and pounds of beef gained per steer for six herds.

between the mean numbers of tabanids and beef weight gains in all pastures, as is graphically shown in figure 5. The regression line shown in figure 5 may represent a simple linear correlation of two vari-

Table 7.—Butterfat production gradients for animals in similar stages of lactation given as difference in pounds butterfat per animal between two successive 30-day test periods. Treatment started end of period II, June 29, and continued through the fourth period, which ended August 28, 1950.

Animal	Deviation between Successive 30-Day Periods		
	I–II	II–III	III–IV
1	−5.3	+14.5	+ 2.2
2	−2.6	+ 5.0	+ 4.4
3	+0.37	+ 8.3	− 1.4
4	−9.5	+ 2.2	+ 7.0
5	−5.5	+ 7.6	− 6.5
6	+0.2	+22.6	−16.2
7	−8.8	+15.0	− 6.0
Mean	−4.45	+10.7	− 2.3

Note: Mean difference for significance; 5% level 8.9; 1% level 12.5. Since total differences in trends are 15.17 and 13.0, both are highly significant.

Table 8.—Average numbers of *Tabanus sulcifrons* and beef weight gains from June 20 to July 27.

Field Number	Range in Number of Tabanids per Steer	Mean Number of Tabanids per Steer	Gain in Weight per Steer	Terrain
1	0.1– 0.2	0.09	90.0	Adjacent to woods
2	1.0– 5.2	3.56	77.0	No trees and on a hill slope
3	2.1–21.0	9.68	66.0	Low with creek and several trees
4	0– 8.2	4.21	72.0	Pasture on slope with two trees and shelter
5	0–10.6	4.90	70.0	On hill with no trees
6	2–27.7	11.83	59.0	Near woods

Note: Field number 1 contained the automatic micro-spray applicator which used about 2.4 ml. of Pyrenone spray concentrate per animal per day.

ables, or it may be non-linear, the result of two phases of loss, the first phase being the result of annoyance by five or fewer tabanids per animal and the second the result of real losses of blood. With the projection of the line one could arrive at a point of no beef gains and a mean horse fly population of between 25 and 100. Actually this point has been reached in previous years on experiment 10 during a severe outbreak of tabanids.

The animals in the adjacent pasture (2) frequently congregated and spent much time huddled along the fence near the spray apparatus. The fly count and weight gain data indicate they may have derived some benefit from the drifting spray mist of the applicator in pasture No. 1. These data on weight gains are preliminary in nature, and, although striking, cannot be considered as conclusive.

The average daily consumption of spray by the automatic micro-spray applicator was approximately 2.4 ml. of concentrate per animal. This device made possible the treatment of a large number of animals with a very small amount of liquid. One gallon of spray concentrate gave 1667 animal-days of protection; it would have treated 16 animals for 100 days. Not only was there great economy in this treatment but tabanid control was better than with the other kinds of applicators tested. This same applicator completely controlled the horn flies and kept the animals free of the few miscellaneous species of tabanids. Needless to say, the results obtained with the automatic spray applicator provoked much interest among the beef cattle breeders of southern Illinois. It seems quite possible that other livestock pests might be effectively controlled by this apparatus, with appropriate changes in nozzle arrangements and spray concentrate formulations.

CONCLUSIONS.—1. *Tabanus sulcifrons* and a few minor species of tabanids were successfully controlled on dairy cattle with sprays containing not less than 0.1 per cent pyrethrins and 1.0 per cent piperonyl butoxide.

2. Analysis of gross data obtained from 25 herds of dairy cattle showed a highly significant beneficial change in butterfat production occurring at the time of treatment and continuing for several weeks. There was a high degree of inverse correlation between changes in butterfat production and horse fly abundance. (A correlation coefficient of $-.747$, with $-.4869$ required for significance at the 1 per cent level.)

3. Animals in continuous lactation showed highly significant changes in the slope of their butterfat production gradients at the time of treatment.

4. An automatic micro-spray applicator made possible the first practical control of tabanids on range beef cattle. The degree of control attained with this applicator exceeded that of all other kinds of applicators tried on beef or dairy cattle.

5. Although data presented in table 8 are considered preliminary, there is some reason to believe that the 20- to 30-pound gain of the treated steers during a 38-day period was significant; especially in light of the high degree of correlation between the mean number of tabanids and weight gains, figure 5.

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Parathion Hazards Encountered Spraying Citrus in Florida

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In 1950 it was reliably estimated that more than 1000 tons of 15 per cent wettable parathion were used on citrus by Florida growers. This general use was due to the fact that not only has parathion been effective for the control of aphids, citrus mealybugs, Florida red scales and purple scales, but also, as contrasted with oil, parathion has no adverse effect upon the production of soluble solids, upon the degreening of fruit, nor upon general tree vigor. Sprays have been applied at dosages ranging from 1 to 2 pounds of 15 per cent wettable powder per 100 gallons, with as much as 2000 gallons being applied per acre. Thus, regardless of the increased cost and increased health hazards from parathion, many growers believed that its use was advantageous.

The application of parathion to citrus presents a unique situation when citrus is compared with other crops. In the Florida citrus industry, there are so-called caretaking organizations which take care of from a few hundred to several thousands of acres of grove. Scalecides are usually applied during only two periods of the year; at post-bloom time, March and April, or during the months of June and July. Under these circumstances spray crews often use parathion daily over a period of from 6 weeks to 2 months or longer. Not only may the citrus spray hand be exposed daily over long periods of time, but the nature of the spray operation is such that his clothing and skin may be saturated with spray all day, every day. Because of the excessive exposure to parathion over prolonged periods of time, the cumulative effect of destroying tissue cholinesterase has been such that parathion poisoning has probably been more prevalent in citrus spray operations than elsewhere. This paper will discuss the cause and history of the cases of parathion poisoning reported during citrus spray operations in 1950 and will present some information on the inter-relationships between exposure to parathion and changes in blood cholinesterase levels.

In 1949 very few precautions were used in handling parathion but no serious illnesses were encountered until September when a man was killed at Lake Placid. His only job was to put parathion and the other spray materials into the tanks of the sprayers. He had been sick with parathion poisoning previously, but had returned to his job in spite of warnings by the attending physician. His death emphasized to the entire citrus industry that precautions must be enforced vigoriously. Precautions were laid down by the Advisory Committee of the Florida Citrus Commission and these were published as a separate leaflet with the 1950 Better Fruit Program. As a result of the enforcement of such precautions parathion poisoning was minimized during 1950. One organization sprayed over 20 tons with only one mild case of poisoning reported. However, in spite of the precautions, a number of cases did occur. In March, 1950, the Citrus Experiment Station began investigating all cases of parathion poisoning and sent report blanks to all major insecticide companies and to most citrus production managers with the request that a form be filled out every time that a laborer was suspected of having parathion poisoning. Forty-eight actual reports were returned, and these probably represented no more than half of the total cases which occurred while spraying citrus. Of these 48, eight were found to be definitely not parathion poisoning and 15 others were highly questionable. In most of the questionable cases the man had handled very little parathion and his symptoms were confined to either headache or nausea. The remaining 25 cases were assumed to be reports of authentic poisoning. It should be emphasized here that in the absence of blood tests for cholinesterase, positive diagnoses could not be obtained. Of 10 cases which were

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[2] Presented at the Denver Meetings of the Association.

reported late during the spraying season and where blood cholinesterase tests were made, only five, or 50 per cent, proved to be actual parathion poisoning. In the absence of such a blood test all 10 would have been diagnosed as parathion illness earlier in the year.

Spray labor was quite cognizant of the potential danger of using parathion, and psychosomatic symptoms were undoubtedly common. During the spring and early summer, laboratories for testing cholinesterase were not available so that physicians were forced to assume parathion in all cases and treat the patients accordingly. Thus, the job of interpreting the data on parathion poisoning is complicated by the difficulty of being unable to determine unequivocally the status of what was not parathion poisoning.

Table 1 gives a breakdown of the type of job in which men were employed when they became ill with parathion. The questionable as well as the authentic cases are shown. It will be noted that among

Table 1.—Type of job performed by 37 men with reported parathion poisoning.

TYPE OF EMPLOYMENT	AUTHENTIC PARATHION POISONING	QUESTIONABLE PARATHION POISONING
Used Hand Spray Gun	11[1]	8
Mixing Materials in Tank	5	3
Both Hand Gun in Mixing	5	1
Speed Sprayer Driver	3[2]	1

[1] Two authenticated by cholinesterase test.
[2] Three authenticated by cholinesterase test.

men handling a spray gun or mixing materials in the spray tank there was a much higher incidence of poisoning than was encountered by Speed Sprayer drivers This is in spite of the fact that probably 75 per cent of the parathion was sprayed by speed sprayers, and, in general, 150 per cent more parathion was applied per day by speed sprayers than by a hand machine. Thus, the incidence among men using hand guns was definitely high. It is somewhat difficult to understand why the man filling supply units (used to carry spray solutions to a Speed Sprayer) should have a higher incidence than the driver. It suggests that spray drift, even of long duration, as experienced by the driver, may not be as dangerous as the relatively short period of exposure to higher parathion concentrations present in dust formulations handled by the man filling the tank.

The time period during which the men handled parathion is shown in table 2. Among the supposedly authentic cases, 80 per cent had more than a week's exposure to parathion, while most of the questionable cases had less than 1 week's exposure. This definitely suggests that parathion exposure in citrus groves should be limited. Temporarily, at least, a week on and a week off the job may be a satisfactory solution. However, considerably more work must be performed with careful studies of cholinesterase changes being correlated with parathion exposure.

Table 2.—Number of days parathion was used before illness occurred.

NO. DAYS	AUTHENTIC PARATHION POISONING	QUESTIONABLE PARATHION POISONING
1–4	3[1]	4
5–7	2	7
8–14	4	0
15–21	4	0
21+	12[2]	2

[1] One case authenticated with cholinesterase test.
[2] Four cases authenticated with cholinesterase test.

Fifty men were used in a study comparing the pounds of parathion handled per day, as correlated with the amount of parathion collected on their respirator filter discs. All data were based on the daily average for a week's exposure. These data are summarized in table 3 and figure 1. The amount of parathion found on the filter disc was not correlated with the pounds of parathion handled per day for any of the three labor categories checked. The hand gun operator would appear to have far greater skin exposure than the speed sprayer operator. This was correlated with the difference in the incidence of parathion poisoning between the two groups. Although they handled comparable amounts of parathion, the supply unit operator got less parathion on his filter discs, but had more poisoning cases than the speed sprayer driver. In the speed sprayer operation, the amount of wind was an important factor in increasing the quantity of spray to which the driver was exposed. These data suggest that handling

Table 3.—Amount of parathion found on respirator filter discs during known exposure periods.

Job	No. Men Checked	Mcg. Parathion per Filter Disc per Day	
		Range	Average
Speed Sprayer Driver	22	16–153	71
Hand Spray Gun Operator	10	26–191	97
Filling Tank	18	0–137	43

concentrated materials may be more hazardous than spraying.

Preliminary studies of the effect of known parathion exposure on blood cholinesterase levels were made. This was accomplished by making blood tests before and immediately following a week of exposure. The pounds of parathion handled per day were known and these were compared with the changes in blood cholinesterase levels.

The red blood cell cholinesterase changes after a 7-day exposure are shown in table 4. There is no correlation between the job performed or pounds of parathion handled per day and cholinesterase change. In fact, it would appear that in these cases there was little real cholinesterase depression effect due to parathion handling. In one case there was a drop of 29 units from 94 to 65 per cent.[1] This man showed definite gastrointestinal symptoms (1). The authors observed him after one day's spraying and his skin and clothing were

Table 4.—Red blood cell cholinesterase change after a v-day exposure as compared with pounds of parathion handled per day.

Job	Parathion Handled per Day	Change in R.B.C. ChE[1]
Speed Sprayer Driver	119 lbs.	− 1
	164	− 8
	210	−15
	213	+ 4
	267	−29
	?	− 3
	?	− 1
Filling Tank	119	+13
	183	−12
	215	− 7
	267	0
	360	+ 5
	407	+14
	?	− 1
Hand Spray Gun Operator	49	0

[1] No. of per cent unit changes. Thus, −8 equals a drop from 11 to 82 per cent of normal amount.

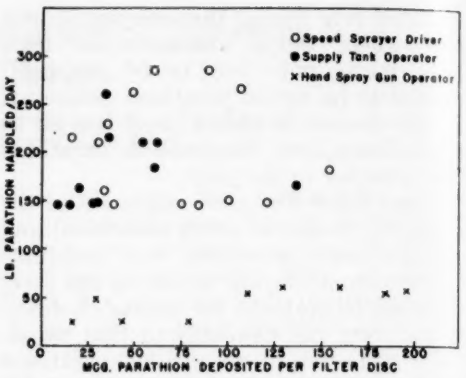

FIG. 1

saturated with spray material. Apparently, he took very little care to stay out of spray drift.

A limited amount of work was performed in the late summer of 1950, which indicated that under conditions where care was taken prolonged exposure could be maintained with no lowering of the blood cholinesterase. Thus, in 13 cases where cholinesterase was checked after exposures of more than one month of regular spraying, red blood cell cholinesterase for these men ranged from 81 to 96 per cent with an average of 88 per cent and plasma cholinesterase ranged from 88 to 110 per cent with an average of 99 per cent. The plasma figures are normal, but the red cell levels may indicate a slight lowering which could be assumed to have been caused by parathion absorption. In at least four instances parathion poisoning apparently occurred when the red blood cell level of cholinesterase was not reduced below 60 per cent of the normal average (Griffiths & Williams 1951). This suggested that in some cases there may be warning symptoms before blood cholinesterase has been seriously lowered. In any case, this opens a new avenue of needed investigation.

Establishment of the route of entry of parathion into the human body during spray operations is extremely important. Unpublished data indicates that animals exposed to parathion vapors in a heavily sprayed grove showed no cholinesterase inhibition and no ill effects over a 10-day exposure period.[2] Over 90 per cent of

[1] All cholinesterase figures are recorded as per cent of normal control average which is 100 per cent.

[2] Experiment carried on cooperatively between the Florida Citrus Experiment Station and the American Cyanamid Company.

the parathion poisoning victims reputedly wore approved chemical type respirators. Although the respirators were not always worn properly, their use coupled with the data from animals exposed to parathion would appear to indicate that most parathion poisoning was due to something besides breathing parathion vapors. Daily clothing changes and a good bath at the end of the day were recommended, but not always practiced. On the basis of the 1950 data the primary route of parathion entry was considered to be skin absorption.

SUMMARY AND CONCLUSION.—Probably over a thousand tons of 15 per cent wettable parathion were used in Florida on citrus during 1950. No deaths were encountered, but 48 reports of supposed parathion poisoning were sent in to the Florida Citrus Experiment Station. Twenty-five of these cases were assumed to be authentic parathion poisoning. Of these, eleven men were using hand spray guns, five were mixing materials in the spray tank, five were using a hand gun and mixing materials, and three were drivers of tractors which pulled the speed sprayers. The pounds of parathion handled per day were not correlated with either the mcg. of parathion per respirator filter disc or changes in red blood cell cholinesterase. Prolonged exposure appeared to be a major contributing factor to the incidence of parathion poisoning. It was concluded that (1) skin absorption was the primary cause of parathion poisoning, (2) spray labor in citrus groves in Florida should not be exposed to parathion sprays for more than a week at a time, and (3) at least a week's interval should occur in between exposure periods.

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Meadow Spittlebug Control with Low and High Volume Insecticide Applications

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The general farmer, who is most concerned with controlling the meadow spittlebug, *Philaenus leucophthalmus* (L.) on legumes, does not own the necessary equipment to engage in field applications of insecticides prepared in wettable powder formulations; nor does the present need for such equipment justify the heavy investment in high volume, high pressure sprayers. However, an increasing number of low volume "weed" sprayers are being sold to the general farmer for weed control work. These have been utilized in Ohio to treat substantial acreages of alfala and red clover meadows for spittlebug control.

Chamberlin & Medler (1949) have shown that 15 to 30 gallon per acre applications of some insecticides at 30 and 40 pounds pressure have been effective in controlling spittlebug nymphs on alfalfa 18 to 24 inches high. Weaver (1950) found that benzene hexachloride in 10 gallons of spray material applied at 30 pounds pressure gave good control of spittlebug nymphs on red clover.

Chamberlin & Medler (1949) reported toxaphene the best material used in their tests in 1948 although chlordane was also effective. In 1947, Chamberlin *et al.* (1948) reported chlordane as the best material tested. Pederson & Sherman (1948) used benzene hexachloride quite effectively to control spittle nymphs on strawberries.

To gain more precise information on the conditions under which low volume applications would be successful and to compare the effectiveness of benzene hexachloride, chlordane, toxaphene, and aldrin, the tests described in this paper were performed at Wooster, Ohio in the spring of 1950.

All of the insecticidal applications described in these tests were applied from a jeep-mounted spray rig with a 13 foot boom with nozzles spaced 20 inches apart. Applications were made at 100, 37, and 9 gallons of spray material per acre. For the 100 gallon per acre applications the spray was applied at 150 pounds per

square inch pressure. The 9 gallon and 37 gallon applications were applied at 30 pounds pressure. The jeep forward speed in every case was 2.4 miles per hour.

The 9 and 37 gallon applications were considered, and are described here, as low volume. The 100 gallon per acre rate was considered high volume. Emulsifiable concentrate materials were used in all of the low volume and in some of the high volume applications. Wettable powders were all applied at 100 gallons per acre. All the materials were commercial preparations. The benzene hexachloride formulations used were all technical grades containing varying amounts of the various isomers. In every case, concentrations were calculated to deliver 0.2 pound gamma isomer per acre.

In order to compare low and high volume applications of insecticides for spittlebug control, two tests were laid out on a cooperator's field containing an alfalfa-red clover-grass mixture. The plots measured 13 by 500 feet. These dimensions were chosen to minimize driving over the field. One series included benzene hexachloride at the rate of 0.2 pound gamma isomer per acre applied as an emulsifiable concentrate in 9 gallons of spray mixture and as a wettable powder in 100 gallons of water. This series was replicated four times. The second series had triplicate plots of chlordane at 1 pound per acre and toxaphene at 1.5 pounds per acre applied at the same two volumes as the benzene hexachloride. Applications of the insecticides in both series were made on May 15 when the plants were 6 to 8 inches high. The three plots treated with toxaphene emulsion, which were the last to receive treatment, were sprayed in a light rain. During the 24 hour interval following treatment more than one inch of rain fell. This provided an excellent check on the effect of rain immediately following insecticide application. Counts of the infested stems were made on May 25, by examining 100 randomly selected stems from each plot. The results are shown in table 1.

Benzene hexachloride and toxaphene gave excellent results in both low and high applications. Although chlordane was inferior to toxaphene and benzene hexachloride, the low and high volume applications were about equal in effectiveness. The rain apparently did not have a detrimental effect upon the control obtained.

Another test of the relative merits of benzene hexachloride and toxaphene was carried out on four contour strips approximately 150 by 1200 feet long. Each strip was divided into two sections each measuring 150 by 600 feet. On May 9, one section of each strip was treated with benzene hexachloride at 0.2 pound gamma isomer per acre, and the other section with toxaphene at 1.5 pounds per acre. The materials used were emulsifiable concentrates in 9 gallons of spray mixture per acre. Each strip had a different meadow mixture but the main components were ladino clover, alfalfa, and various grasses. The plants were from 8 to 12 inches high when treated. Since the main object of the original plot layout was to test the relative merits of the meadow mixtures only a small area in the center and ends of each strip could be left untreated in this test. These small areas served as checks.

On May 13, 100 stems were examined

Table 1.—A comparison of wettable powders and emulsifiable concentrates of benzene hexachloride, toxaphene, and chlordane applied in high and low volume for spittlebug control.

Insecticide	Concentration per Acre	Per Cent Infested Stems, May 25	Per Cent Reduction
BHC 10% gamma emulsion	.2 lb. gamma	0.50	99.1
10% gamma wettable powder	.2 lb. gamma	0.25	99.5
Check—no treatment		54.50	—
Toxaphene 60% emulsion	1.5 lbs. actual	0.66	99.9
25% wettable powder	1.5 lbs. actual	0.33	99.9
Chlordane 60% emulsion	1.0 lb. actual	12.0	80.3
40% wettable powder	1.0 lb. actual	9.0	85.2
Check—no treatment		61.0	—

Table 2.—A comparison of benzene hexachloride, chlordane, toxaphene, and aldrin for spittlebug control.

INSECTICIDE	CONCENTRATION PER ACRE	DATE APPLIED	BUGS PER STEM	PER CENT REDUCTION	YIELD[1] LBS./A	PER CENT INCREASE
BHC 10% gamma wettable powder	.2 lb. gamma	4-27	.06	98.4	3420	36.7
BHC 10% gamma wettable powder	.2 lb. gamma	5-13	.11	97.0	2876	18.9
Toxaphene 25% wettable powder	1.5 lbs. actual	5-13	.04	99.0	3376	34.9
Chlordane 40% wettable powder	1.0 lb. actual	5-13	.29	92.3	3348	33.8
Aldrin 25% wettable powder	.25 lb. actual	5-13	.47	87.5	3126	24.9
Check	—	—	3.74	—	2502	—

Yield L.S.D. at 5 per cent = 510.
[1] 20 per cent moisture hay.

from each of the two treated and check areas of each strip. Per cent of stems infested in the various areas were benzene hexachloride 14.5; toxaphene, 18.2; and untreated, 86.0. From the standpoint of acceptable control either material was satisfactory but the results were inferior to those obtained in other tests in which the sprays were applied when the plants were less than eight inches high.

In another series of plots containing an alfalfa-ladino clover-timothy mixture, wettable powder formulations of benzene hexachloride, aldrin, toxaphene, and chlordane were applied. The plots measured 8 by 48 feet and were contained in four randomized blocks.

Benzene hexachloride was applied at two different dates, April 27 and May 13. The other three insecticides were used on May 13. The plants were less than 4 inches high on April 27 and 6 to 8 inches high on the latter date. April 27 was chosen as the time for the first benzene hexachloride treatment because the first young spittle insects were found on that date in the 1950 season. The use of this treatment was to determine if the insecticide would be effective throughout the hatching period. The peak of hatching of spittlebug nymphs in the Wooster area occurred about May 8 and most of the hatching was complete by May 13.

Insect counts were made on June 1 and 2 by examining 25 stems of alfalfa chosen in a random fashion from each plot. The number of young insects found on each stem was recorded. The data are presented as the average number of bugs per stem from 100 examined.

Yield records were taken June 14 by cutting the entire plot and weighing the green material immediately. Samples of green material were dried and all yields computed on the basis of 20 per cent moisture hay. The data are shown in table 2.

The early application of benzene hexa-

Table 3.—Time and volume of application of benzene hexachloride at 0.216 gamma isomer per acre to control spittlebug nymphs.

DATE	VOLUME GALS./A	PRESSURE LBS./SQ. IN.	FORMULATION	BUGS PER STEM	PER CENT REDUCTION	YIELD[1] LBS./A	PER CENT INCREASE
5-13	100	150	10% gamma wettable powder	.04	98.8	3200	44.6
5-13	9	30	10% gamma emulsion	.37	88.9	3171	43.3
5-24	9	30	10% gamma emulsion	.57	82.7	2716	22.7
5-24	37	30	10% gamma emulsion	.07	97.9	3274	48.0
5-24	100	150	10% gamma emulsion	0+	99.9+	3199	44.6
Check—no treatment				3.32	—	2212	—

Yield L.S.D. at 5 per cent = 620.
[1] 20 per cent moisture hay.

chloride was apparently effective on both the early nymphs and those which hatched later. Timing the spray this early had a definite advantage since the plants were less than four inches high and coverage of the crowns of the plants where the young insects congregate was excellent. The insecticide residue likely to remain at harvest on forage crops so treated should be low.

Benzene hexachloride at 0.2 pound gamma isomer per acre and toxaphene at 1.5 pounds per acre, both applied on May 13, were the best materials tested. However, all of the insecticides used reduced the nymphs to the point where those remaining did not reduce the yield enough to make an economically important difference. Eighty-five per cent control based on bugs per stem was enough to reduce damage to a negligible level.

Analysis of variance of the yield data shows the yield differences due to treatment to be statistically significant. Application of the least significant difference is not of much advantage since no treatment mean is different from the mean ranking next to it. The method of Tukey (1949) for comparing individual means has been applied and the mean yield for the check was found to "straggle" from the rest. The means from treated plots could not be separated although Tukey's test showed them to be non homogeneous.

A set of plots containing the same crop mixture and similar to those in the preceding experiment was treated with different volumes of spray mixture of benzene hexachloride on May 13 and May 24 to control spittlebug nymphs. Benzene hexachloride was applied at 0.2 pound gamma isomer per acre in every case. On May 13, the plants were 6 to 8 inches high and on May 24 were 12 to 18 inches high. Records were taken at the same time and in the same way as in the test above. The results are shown in table 3.

The 37 and 100 gallon per acre rates gave excellent control while the 9 gallon rate was less effective, especially when applied on May 24. Increasing the volume from 9 to 37 gallons was apparently enough to give good control in the May 24 application in spite of the taller foliage.

Mean yield differences in table 3 were found to be statistically significant. Tukey's method separated the check mean as straggling excessively while the other five treatment means were placed in a non homogeneous group.

SUMMARY.—Benzene hexachloride applied to give 0.2 pound gamma isomer per acre in 37 and 100 gallons of spray mixture gave excellent control of spittlebug nymphs even when applied to foliage as much as 12 inches high. The same insecticide contained in 9 gallons of spray mixture was less effective on tall plants. Yields of a mixed meadow crop were increased 22 to 48 per cent by treatment.

Benzene hexachloride applied at 0.2 pound gamma isomer per acre when the first spittle nymphs appeared (April 27) gave sufficient residual action to control 98 per cent of the nymphs including those which hatched after treatment.

Benzene hexachloride, 0.2 pound gamma isomer, and toxaphene 1.5 pounds per acre applied in either high or low volume when the plants were less than 8 inches high gave excellent control of spittlebug nymphs. Chlordane and aldrin at 1.0 pound and .25 pound per acre, respectively, gave less control but reduced the insect numbers to the extent that the yield were not seriously affected by those that survived the treatments.

Rain immediately following applications of benzene hexachloride, toxaphene, and chlordane apparently did not reduce the efficacy of the materials in controlling spittlebug nymphs.

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Use of Radioactive Tracers in Studies of Penetration and Metabolism of DDT in House Flies[1,2,3]

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The penetration of a toxicant through the cuticle of an insect and its deposition or decomposition within the insect have been of interest to many workers. Richards & Cutkomp (1946) proposed the hypothesis "that chitinous cuticles facilitate the entry of DDT into the animal body by selectively concentrating the compound by adsorption phenomena." Ferguson & Kearns (1949) found that milkweed bugs, *Oncopeltus fasciatus* (Dall.), injected with 100 μgm (micrograms) of DDT in acetone solution metabolized 80 to 100 per cent of the toxicant within 90 minutes. The extracts of these bugs were nontoxic to house flies, *Musca domestica* L. Colorimetric and ultraviolet spectro-analyses of the treated bugs failed to show the presence of 2, 2-bis(*p*-chlorophenyl)-1, 1-dichloroethylene and 2, 2-bis(*p*-chlorophenyl)-acetic acid (hereinafter referred to as *DDE* and *DDA*), products of metabolism recovered from various tissues and products of warm-blooded animals treated with DDT. Sternburg *et al.* (1950) showed by chemical analysis that DDT-resistant house flies rapidly metabolized DDT to DDE, and that small amounts of DDT were actually present within the flies up to 57 hours after treatment. Perry & Hoskins (1950) recorded similar results.

The present paper gives results of studies against house flies with a sample of radioactive DDT[4] that contained 0.25 millicurie of C^{14} (radioactive carbon) per gram as a tracer randomly distributed through the benzene rings. Owing to the low specific radioactivity of the preparation, DDT-resistant flies were used in all tests unless stated otherwise. The seventy-sixth, seventy-seventh, and seventy-eighth generations of the Orlando No. 1 colony of resistant flies (Lindquist & Wilson 1948, King & Gahan 1949) were used in most of the tests. This strain of flies was not subjected to DDT sprays for selection of resistant individuals after the seventy-fifth generation. The studies included topical treatment of individual flies with known amounts of radioactive DDT and exposure of flies to residues of the DDT. The amounts recovered in acetone washes and extracts of the macerated flies were determined by radioactivity measurements and by bioassays. Over 800 preparations were assayed for their content of C^{14}. Radioactivity was measured in counts per minute (cpm), with a thin-walled (1.85 mg. per cm.^{2}) Geiger-Müeller tube attached to a commercial-model 64 scaler. Several thousand house flies, all females, as well as numerous mosquito larvae were used in the bioassays.

TESTS WITH FLIES TREATED BY TOPICAL APPLICATIONS—Acetone solutions of the radioactive DDT were applied to the dorsal surface of the thorax of the flies while they were immobilized with carbon dioxide. The applications were made with a 0.25-ml. tuberculin syringe attached to a micrometer (March & Metcalf 1949). Dosages of 15 μgm of radioactive DDT (1.5 mm.^{3} of 1 per cent solution in acetone) per fly caused less than 100 per cent mortality in 24 hours. At the end of this time the surviving and dead flies were separated and prepared for radioactive essay. The primary objective was to determine what per centage of the DDT would penetrate the insects. Accordingly, individual flies were washed (shaken vigorously in a vial) for 15 seconds in 5 ml. of acetone. The wash was evaporated in metal counting dishes 1 inch in diameter. Each fly was then macerated with a glass rod in about 3 ml. of acetone for about 5 minutes to extract DDT or metabolites from the tissues. The extract from the macerated flies was decanted into metal counting dishes and evaporated. The DDT recovered in the wash and the extract was then determined from the radioactivity

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[2] Published as Technical Paper No. 623 with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution of the Department of Agricultural Chemistry.

[3] Presented at the meeting of the Pacific Slope Branch of the American Association of Economic Entomologists at Santa Cruz, Calif., June 14–16, 1950.

[4] Sample obtained through courtesy of S. B. Hendricks, Bureau of Plant Industry, Soils, and Agricultural Engineering.

Table 1.—Recovery of radioactive chemicals in extract of macerated tissues and external wash of house flies treated topically or exposed for 24 hours to residues of radioactive DDT.

Preparation	Topical Applications of 15 Micrograms (165 cpm.) per Fly (Average of 44 Flies)				Exposure to Residues of 5 Mg. per Square Foot (Average of 17 Lots of 10 Flies)		
	Cpm	Micrograms Radioactive Chemicals Recovered, on Basis of Cpm	Distribution Recovered Radioactive Chemicals (per cent)[1]	Per Cent Original DDT Recovered	Cpm per Fly	Micrograms Radioactive Chemicals Recovered on Basis of Cpm	Distribution Recovered Radioactive Chemicals (per cent)[1]
Flies surviving treatment:							
Extract	23	2.1	18	—	2.32	0.21	87
Wash	106	9.6	82	—	.34	.031	13
Total	129	11.7	—	78			
Flies killed by treatment:							
Extract	25	2.3	17	—	2.86	.26	76
Wash	120	10.9	83	—	.88	.08	24
Total	145	13.2	—	88			
Flies killed in boiling water before treatment with DDT:							
Extract	3	.3	2	—			
Wash	148	13.4	98	—			
Total	151	13.7	—	91			

[1] Based on the amount of DDT recovered as determined by cpm.

measurements. Numerous measurements of 15 μgm samples of radioactive DDT showed that, with the Geiger-Müeller counter employed, 1 μgm was equivalent to 11 cpm.

It was soon found that the wash was highly radioactive whereas the extracts gave low readings, an indication that most of the DDT remained on the surface of the insects. It is believed that most, if not all, of the DDT was removed from the exterior of the fly, because there was no appreciable difference in counts whether washing was performed for 1 second or 15 seconds or whether different solvents were used. To determine whether acetone extracts DDT from within the fly, some insects were injected with 15-μgm dosages and then washed in acetone. Very little DDT was washed out, an indication that the technique employed was satisfactory for determining the amount of DDT that penetrated the insect.

The results of these tests are given in table 1. The total count for the extracts of macerated tissues and external wash of the flies surviving the DDT treatment was less than for those that died. From the total counts for the extracts and washings, it was found that 80 and 83 per cent of the radioactive chemicals was recovered in the wash. The total recovery of the DDT applied (extract plus wash) averaged 78 per cent for the surviving flies and 88 per cent for the dead flies. The failure to recover all the DDT may have been due to several factors, including losses of DDT in fly excretions, losses during transfer of washes from vial to counting dish, and incomplete extractions.

That DDT applied on the thorax actually remains on the exterior of the surviving flies was demonstrated by permitting regular-colony (susceptible) flies to crawl over the backs of the treated resistant flies for 50 minutes. After 24 hours all the regular flies were dead. If the acetone wash did not remove DDT from within the fly, the resistant flies carried 82 per cent of the dosage on their backs, or at least on their exterior, 24 hours after treatment. However, in other tests with a dosage of 2.5 μgm of DDT none of the flies were killed but 60 per

Table 2.—Results of bioassays, employing mosquito larvae, obtained with acetone extracts of tissues from DDT-resistant flies treated topically with 15 μgm of radioactive DDT per fly.

PREPARATION	AVERAGE CPM PER FLY	MICROGRAMS RADIOACTIVE CHEMICALS RECOVERED ON BASIS OF CPM	PER CENT KILL OF MOSQUITO LARVAE	ESTIMATED PER CENT OF DDT METABOLIZED[1]
	Series 1 (average of 6 tests)			
Extract of surviving flies	14.8	1.35	49	63
Extract of flies that died (53%)	18.8	1.71	62	71
Known dosage of DDT:				
1 μgm	—	—	90	—
0.5 μgm	—	—	50	—
	Series 2 (average of 9 tests)			
Extract of surviving flies	24.1	2.19	79	50
Extract of flies that died (60%)	27.3	2.48	89	60
Known dosage of DDT:				
1 μgm	—	—	90	—
0.5 μgm	—	—	50	—

[1] Based on kill of mosquito larvae exposed to radioactive material as compared with comparable kill obtained with known dosages of DDT.

cent of the DDT was recovered in the wash.

The penetration of DDT into flies killed prior to treatment was determined by treating such flies each with 15 μgm of radioactive DDT. Table 1 shows that nearly all the DDT that was recovered occurred in the wash. However, the extract showed sufficient radioactivity to indicate that about 2 per cent of the DDT penetrated the dead insects.

TESTS WITH FLIES EXPOSED TO DDT RESIDUES.—Presumably flies pick up DDT through their appendages when allowed to walk over a dry residue of this insecticide. To determine the amount absorbed in this way, resistant flies were exposed to a residue of 5 mg. of radioactive DDT per square foot in a glass jar. The exposure, 3 to 6 hours, was adjusted to give less than 100 per cent kill in 24 hours. The surviving and dead flies were prepared for radioactivity measurements in the same way as those treated topically, except that it was necessary to use groups of 10 flies to obtain sufficiently high counts to be recorded on the scaler.

Table 1 shows that lower counts were obtained with the surviving flies than with the flies that succumbed to the treatment.

The trend is similar to that obtained with topically treated flies. However, the wash of the flies exposed to a residue contained only a small portion of the total amount of radioactive material on or in the flies, thus differing greatly from the flies treated topically. The counts for the extract were considerably lower than for the topically treated flies. An average of 2.1 μgm of DDT or metabolites was present in the extract of surviving flies that were treated topically, whereas only 0.21 μgm was present in that of flies exposed to the residue. In the extracts of the flies that died, 2.3 μgm were recovered from those treated topically and 0.26 μgm from those exposed to the residue. According to these data, approximately 10 times as much absorbed DDT is required to cause approximately 50 per cent mortality when the treatment is made on the thorax as when the flies walk on a treated surface and absorption is through the feet.

BIOASSAY OF TOPICALLY TREATED FLIES.—Many tests were made in which regular-colony house flies were exposed in counting dishes contaminating residues from either the external wash or the extract of the topically treated resistant flies. The residues from the washes killed these flies rapidly, but those from extracts of macerated flies showed little or no toxicity to flies confined for 24 hours. No regular-colony flies placed in dishes containing 1 μgm of DDT were killed, but some mortality occurred in dishes containing 2 μgm. These results suggested that in an effort to estimate the amount of DDT metabolism a more

sensitive insect should be used.

Two series of tests were therefore made with fourth-stage larvae of floodwater *Aëdes* mosquitoes reared in the laboratory by standard methods. Treated flies were thoroughly washed with acetone to remove the DDT that had not penetrated. The flies were then macerated and extracted with acetone. After the radioactivity of the extracts from individual macerated flies had been determined, the material in each counting dish (from one fly in each case) was dissolved in 2 ml. of acetone and added to tap water in a beaker so that the total volume was 200 ml. Twenty mosquito larvae were placed in each beaker. Concurrently, known dosages of technical DDT were used to establish comparisons. A few tests made with the radioactive DDT applied in metal counting dishes and subsequently rinsed into test beakers showed a slightly lower kill of mosquito larvae than did the acetone solutions of DDT used as checks. The test containers were kept at a constant temperature of 80° F. Mortality readings were taken after 48 hours. The mortality of untreated larvae was less than 5 per cent and extracts of untreated flies did not kill mosquito larvae. The washes from the treated flies were tested in a few cases, but it was necessary to make high dilutions in order to kill less than 100 per cent of the larvae. The results with the extracts are given in table 2. In the first series of tests the extracts of the surviving flies killed about the same percentage of mosquito larvae as the 0.5-μgm dosage of DDT. The difference between this dosage and 1.35 μgm, the amount of radioactive chemicals recovered, is therefore considered to be the nontoxic material metabolized by the flies. This difference, 0.85 μgm, is 63 per cent of the total recovered DDT or metabolites. To confirm this deduction separate experiments were run to determine the toxicity of DDE and DDA, the known metabolites of DDT. These compounds showed no toxicity to the mosquito larvae when used at 2 μgm in 200 ml. of water (0.01 p.p.m.). It is believed that the material that proved toxic to the larvae was unmetabolized DDT.

The results obtained with the flies in this series that died were similar to those obtained with the survivors. It is estimated that 71 per cent of DDT that penetrated the insects was metabolized. In the second series of tests it was estimated that the surviving flies showed 50 per cent and dead flies 60 per cent metabolization of DDT. Sternburg *et al.* (1950) identified approximately the same percentage of DDT within treated flies by means of chemical analysis.

BIOASSAYS OF FLIES EXPOSED TO RESIDUES OF RADIOACTIVE DDT.—Bioassays were made to determine the presence of the DDT or its toxic metabolites within house flies exposed to residues of radioactive DDT. The flies were washed and macerated, and radioactivity counts of the extracts were made as described previously. Each dish was used for tests on mosquito larvae by the same procedure that was followed for the bioassays of topically treated flies. The results are given in table 3. Here again untreated mosquito larvae used as checks showed less than 5 per cent mortality.

In the first series of tests the external washes of surviving and dead flies, containing 0.22 and 0.78 μgm of DDT (not shown in table), gave kills of mosquito larvae nearly proportional to those given by the known dosage of 0.5 μgm of DDT. This was expected, since metabolism, or breakdown, of DDT would not be likely on the exterior of the flies. The extracts, however, containing 2.2 and 2.6 μgm for the surviving and dead flies, respectively, gave kills close to that obtained with 0.5 μgm of DDT. The differences, 1.7 μgm for the surviving and 2.1 μgm for the dead flies, indicate that 77 and 81 per cent of the total absorbed DDT were metabolized to nontoxic products. The second and third series gave similar results. The mortality of untreated mosquito larvae was less than 5 per cent.

If dosage-mortality curves are constructed from the results of these tests, the mortality for the washes ranges from 15 per cent with 0.15 μgm to 90 per cent with 0.95 μgm, and for the extracts from 31 per cent with 1.64 μgm to 85 per cent with 3.36 μgm of DDT.

TOPICAL APPLICATION AND BIOASSAY OF REGULAR-COLONY FLIES.—Topical applications of radioactive DDT were also made in similar tests to determine the degree of metabolism in regular-colony flies. The results are summarized in table 4. Dosages of 2 μgm on 10 flies (0.2 μgm per fly) killed 88 per cent of the flies, and 15

Table 3.—**Results of bioassays, employing mosquito larvae, obtained with acetone extracts of tissues from DDT-resistant flies exposed to residues (5 mg. per square foot) of radioactive DDT.**

PREPARATION	CPM	MICROGRAMS RADIOACTIVE CHEMICALS RECOVERED ON BASIS OF CPM	PER CENT KILL OF MOSQUITO LARVAE	ESTIMATED PER CENT OF DDT METABOLIZED[1]
	Series 1 (average of 5 tests)			
Extract of surviving flies	24	2.2	54	77
Extract of flies that died	29	2.6	63	81
Known dosage of DDT:				
1 μgm	—	—	90	—
0.5 μgm	—	—	66	—
	Series 2 (average of 2 tests)[2]			
Extract of surviving flies	20	2.7	88	63
Extract of flies that died	37	3.36	85	70
Known dosage of DDT:				
1 μgm	—	—	95	—
	Series 3 (average of 5 tests)			
Extract of surviving flies	18	1.64	31	70
Extract of flies that died	23	2.1	26	76
Known dosage of DDT:				
1 μgm	—	—	85	—
0.5 μgm	—	—	55	—

[1] Based on kill of mosquito larvae exposed to radioactive material as compared with comparable kill obtained with known dosages of DDT.
[2] Eight flies per dish instead of 10.

μgm on 30 flies (0.5 μgm per fly) killed all of them. On the basis of kill of mosquito larvae with the fly extracts, about 31 per cent of the DDT metabolized to nontoxic material in flies that survived treatment and 70 per cent in those that were killed. These values in general are similar to those obtained for the resistant flies. This finding is of importance since it suggests that susceptible flies as well as resistant ones can metabolize DDT. Sternburg *et al.* (1950) found that susceptible flies could not metabolize DDT to form DDE or DDA, whereas resistant flies could.

SUMMARY.—Penetration of an insecticide through the cuticle of resistant house flies *Musca domestica* L., was stud-

Table 4.—**Results of bioassay tests with acetone extracts of tissues from regular-colony flies (DDT-susceptible) treated topically with radioactive DDT. Average of 3 tests.**

PREPARATION	CPM	MICROGRAMS RADIOACTIVE CHEMICALS RECOVERED ON BASIS OF CPM	PER CENT RECOVERED RADIOACTIVE CHEMICAL IN EXTRACT	PER CENT ORIGINAL DDT RECOVERED	PER CENT KILL, MOSQUITO LARVAE	PER CENT DDT METABOLIZED[1]
	0.2 μgm of DDT per fly (10 flies per lot)					
Extract of surviving flies	8	0.73	100	36	40	31
Extract of flies that died (88%)	19	1.72	93	86	62	71
Known dosage of DDT:						
1 μgm	—	—	—	—	90	—
0.5 μgm	—	—	—	—	52	—
	0.5 μgm of DDT per fly (30 flies per lot)					
Extract of flies that died (100%)	37	3.36	62	36	97	70
Known dosage of DDT:						
1 μgm	—	—	—	—	95	—

[1] Based on kill of mosquito larvae exposed to radioactive material as compared with comparable kill obtained with known dosages of DDT.

ied by applying 15 μgm of radioactive DDT. After 24 hours both the dead and surviving flies were washed in acetone to remove exterior DDT, and then macerated and the DDT or metabolites extracted with acetone. The quantities of DDT recovered in the wash and extract were determined by radioactivity measurements and calculating the equivalent weights and percentages.

From the flies surviving the topical treatment 78 per cent of the DDT applied was recovered and 82 per cent of the recovered DDT was in the wash. Of the flies given a topical treatment an average of 2.1 and 2.3 μgms of DDT or toxic metabolites was recovered respectively from surviving and dead flies. Approximately one-tenth less DDT or metabolites was recovered from the flies exposed to a residue.

Bioassays of the fly extracts with mosquito larvae as the test insects showed that 63 per cent of the total DDT absorbed by topically treated surviving flies was nontoxic and therefore metabolized. The 27 per cent that was toxic was probably DDT, since neither of the metabolic products, 2,2-bis(*p*-chlorophenyl) acetic acid or 2,2-bis(*p*chlorophenyl)-1, 1-dichloroethylene, killed mosquito larvae. In the dead flies 71 per cent of the DDT was metabolized. The flies treated with the residue showed approximately the same degree of metabolization of DDT.

In tests with susceptible flies approximately 31 to 71 per cent of the DDT that penetrated the cuticle was metabolized to a nontoxic product, which is a rate of metabolism similar to that occurring in the resistant flies.

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Insect Transmission of Citrus Quick-Decline Virus[1,2]

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Citrus quick decline is a disease of citrus which is particularly destructive to trees of sweet orange, *Citrus sinensis* (L.) Osbeck, growing on sour orange, *Citrus Aurantium* L., rootstock. This disease was shown by Fawcett & Wallace (1946) to be caused by a virus. Quick decline is one of a group of similar diseases, of which tristeza is the best known. The first indication of these diseases was noted in South Africa before 1900, when sour orange rootstocks were tried in that area. The virus or virus group may be native to southern Africa. The disease appeared in Java in 1928, in Argentina about 1930, and in Brazil in 1937. Quick decline was first noted in California in 1939, and the similar "bud union decline" appeared in Australia in 1941.

Meneghini (1946) first demonstrated transmission of the tristeza virus by the brown citrus aphid, *Aphis citricidus* Kirkaldy. His discovery has been confirmed by several workers in Brazil, Argentina, South Africa, West Africa, and Australia. This aphid occurs in central and southern Africa, in southeastern Asia, including Japan and India, in many

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[2] Paper No. 662, University of California Citrus Experiment Station, Riverside, California.

East Indian and Pacific islands, Australia, New Zealand, Mediterranean Europe, and in several South American countries. Since *A. citricidus* has never been taken in the United States of America, it is evident that some other vector is responsible for the transmission of the quick-decline virus in California.

SURVEY.—A survey of sucking insects present on citrus in southern California was begun in the spring of 1945 and continued through 1949. Sticky-board traps of the type devised by Kaloostian & Yeomans (1944) were used to make most of the collections. Winged insects with sucking mouthparts were removed from the boards and prepared for identification by the authors or by entomologists in the Division of Entomology of the California Department of Agriculture, or by the Division of Insect Identification of the U. S. Bureau of Entomology and Plant Quarantine, or by various specialists.[3]

Four sticky-board traps were hung just within the foliage of each of two citrus trees in each of six locations in southern California. Some of these were in areas where quick-decline spread has been rapid, and some were in areas where the spread has been slow. The traps were changed every two weeks.

The number of species of various insect groups taken in collections from the sticky-board traps are shown in table 1. The 20 insect species taken most often are listed in table 2. Since taking of one or more specimens in a location over a 2-week period is reported as a "collection," these tables do not give an accurate picture of the relative abundance of the species. One set of traps often caught a hundred or more specimens of a common species.

The majority of the species taken in collections from the sticky-board traps were represented only by casual specimens passing through the trees. The more common of these could not be ignored, since most sucking insects feed at least momentarily on almost any plant upon which they alight. If one of these comparatively rare insects passing through an orchard happened to be an efficient vector, it could easily account for the observed spread of the virus. The rate of spread of quick decline in an orange orchard is actually slow, 20 new infections per acre per year being about standard for areas in which the spread is rapid. The same rate of spread in a carrot or wheat field would not be noticed.

The green citrus or spirea aphid, *Aphis spiraecola* Patch, was the insect taken most often. It lives almost exclusively on citrus trees in this area. The second most common species, *Empoasca arida* DeLong, does not breed on citrus trees but will feed on them while building up on weeds. The green peach aphid, *Myzus persicae* (Sulz.), has a very wide host range; it breeds on

Table 1.—Number of insect species taken in collections from sticky-board traps hung in citrus trees in southern California, 1945 through 1949.

GROUP	SPECIES	COLLECTIONS[1]
Aphids	124	2,431
Cicadellids	102	3,026
Thrips	27	1,139
Psyllids	20	60
Fulgorids	7	22
Membracids	6	11
Cercopids	3	5
Mirids	18	170
Piesmids	1	2
Pentatomids	1	1
Lygaeids	5	19
Coreids	2	2
Anthocorids	2	4
Totals	318	6,892

[1] The taking of one or more specimens in a single location over a 2-week period is termed "a collection."

[3] The authors acknowledge with sincere appreciation the identifications made by Mr. H. H. Keifer and his associates, by Dr. P. W. Oman, Miss Louise Russell, and Dr. D. D. Jensen.

Table 2.—Insect species most commonly taken on sticky-board traps in citrus trees in southern California, 1945 through 1949.

SPECIES	NUMBER OF COLLECTIONS[1]	GROUP
Aphis spiraecola Patch	390	Aphid
Empoasca arida DeLong	327	Cicadellid
Myzus persicae (Sulz.)	296	Aphid
Frankliniella moultoni Hood	254	Thrips
Thrips tabaci Lind.	215	Thrips
Limothrips cerealium Hal.	214	Thrips
Aphis gossypii Glover	185	Aphid
Rhopalosiphum pseudobrassicae (Davis)	180	Aphid
Scaphytopius irroratus (Van Duzee)	167	Cicadellid
Deltocephalus fuscinervosus Van Duzee	151	Cicadellid
Empoasca abrupta DeLong	149	Cicadellid
Ollaranus strictus (Ball)	136	Cicadellid
Aceratagallia curvata Oman	122	Cicadellid
Aceratagallia longula (Van Duzee)	117	Cicadellid
Brevicoryne brassicae (L.)	116	Aphid
Empoasca solana DeLong	112	Cicadellid
Aphis maidis Fitch	103	Aphid
Erythroneura variabilis Beamer	101	Cicadellid
Toxoptera aurantii (Fonsc.)	99	Aphid
Phytocoris conspurcatus Knight	99	Predaceous mirid

[1] The taking of one or more specimens in a single location over a 2-week period is termed "a collection."

citrus and on most other broad-leaved plants in the groves. The western flower thrips, *Frankliniella moultoni* Hood, is also found on a wide range of host plants and is common in citrus flowers. Of the other 16 insect species most commonly taken, only the melon aphid, *Aphis gossypii* Glover, and the black citrus aphid, *Toxoptera aurantii* (Fonsc.), breed on citrus.

TRANSMISSION TESTS.—An effort was made to use species of insects in the transmission tests roughly in the proportion that they were caught on the traps. It was reasoned that since a certain spread was taking place, a rare insect would have to be proportionally more efficient than a common insect to cause it. A part of this efficiency could be the result of activity and feeding habits, but most of it would probably be due to inherent ability to transmit the virus.

In the transmission tests both field-collected and insectary-reared insects and mites were used. They were fed on trees known to be infected with the quick-decline virus. These were either sick orange trees on sour orange root, or healthy-appearing orange trees on sweet orange root from which the virus had been recovered. It has been shown by Fawcett & Wallace (1948) that orange trees on sweet orange root can be symptomless carriers.

The insects and mites were usually fed for a week or more on the infected trees, but the period was shortened to as few as 2 days for species that do not live well on citrus. Test trees were of the following types: Valencia orange on sour orange; Valencia on Bittersweet sour orange; Valencia on Khoubs-el-Asia; Pera sweet orange on Bittersweet; Pera on Khoubs-el-Asia; and, recently, Mexican (West Indian) lime seedlings. Early in the work, commercial, balled nursery trees were used, but as the work progressed the size and age of the experimental trees were reduced until some have been only 1 inch high at the time of feeding the insects on them. Of necessity the first transmission tests were made on trees growing under field conditions. Later, two large screened houses were built to protect the test trees from natural infection. Almost all the test trees have been set in the ground. The insects were allowed to remain 2 weeks to 2 months on the test trees, and were then killed by nicotine spray. Many insects did not live that long.

By November 1, 1950, we had conducted 2187 transmission tests, using 411,435 insects and mites of 312 species. A partial breakdown of the data is shown in table 3. Some of the species listed were included inadvertently in field-collected lots of similar insects. Most of the insect species taken on the traps were used, although some species did not live long enough on citrus to permit transmission tests, an outstanding example being the turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis).

The most difficult part of the project has been to obtain early, definite symptoms. Nursery trees of susceptible stock-

Table 3.—Insects and mites used in transmission tests to find the vectors of quick decline of orange trees.

GROUP	TESTS	SPECIES	INSECTS
Aphids	654	42	363,092
Cicadellids	958	170	20,021
Membracids	361	16	8,263
Fulgorids	65	29	670
Psyllids	36	18	1,766
Cercopids	12	4	125
Aleyrodids	3	2	48
Cicadas	4	3	20
Tingids	4	1	600
Coccids	16	4	10,091
Lygaeids	11	2	449
Mirids	11	5	141
Pentatomids	2	2	11
Corizids	2	1	23
Thrips	35	6	5,474
Tetranychids	6	2	510
Beetles	7	5	131
Totals	2,187	312	411,435

Table 4.—Insect species used in transmission tests on the 18 test trees that have shown definite quick-decline symptoms.

SPECIES	NUMBER OF TREES SHOWING SYMPTOMS
Aphis gossypii Glover	13
A. gossypii and *Spissistilus franciscanus* (Stål) *nigricans* (Van Duzee)	1
A. gossypii and *Spissistilus festinus* (Say)	1
A. gossypii, Spissistilus franciscanus nigricans, and *Spissistilus festinus*	1
Spissistilus franciscanus nigricans and *S. festinus*	1
Stictocephala spp.[1]	1

[1] Three undescribed species.

scion combinations planted in the field show reasonably good symptoms after periods of 15 to 30 or more months following inoculation. Smaller trees planted inside the screen house show symptoms of varying intensity after 3 to 12 months. After the appearance of symptoms, the trees sometimes reach a condition of equilibrium in which the symptoms are obscure. It seems probable that under certain weather conditions trees may reach this state of equilibrium without showing recognizable symptoms.

The insect species used in transmission tests on the 18 test trees that have shown definite quick-decline symptoms are listed in table 4. Sixteen of these trees had *Aphis gossypii* placed on them, either alone or in combination with membracids. Two trees had membracids only. *Spissistilus* (*Stictocephala*) *festinus* (Say) is the three-cornered alfalfa hopper. The three undescribed species of *Stictocephala* referred to in this table belong to the *Stictocephala* (*Ceresa*) *albidosparsa* (Stål) group.

From the results of these studies it is concluded that the melon aphid, *Aphis gossypii*, is a vector of the virus of citrus quick decline. There may be other vectors. In fact, considerable suspicion attaches to various species of membracids, but as yet the evidence is insufficient to warrant considering them vectors.

Aphis gossypii appears to be a relatively inefficient vector. Because of the difficulty in reading symptoms and their delay in appearance, it is not possible to give exact figures for the present tests. The first 20 tests, involving about 3200 melon aphids, resulted in two transmissions. This indicates an efficiency of about 1 in 1600. These figures are preliminary but they serve to indicate that this aphid is much less efficient in its transmission of the quick-decline virus than is *A. citricidus* in transmitting the tristeza virus. In studies with *A. citricidus* in Brazil, Bennett & Costa (1949) report an efficiency of better than 1 in 100.

CITRUS APHIDS.—During the main citrus aphid season (March and April) of 1950, a survey of aphid populations was conducted throughout the southern and central California citrus districts. Orchards were sampled by counting the number of each species of aphid found on 10 twigs on each of 10 trees. Samples were taken at random around each tree, at a height of about 5 feet from the ground. Results, segregated by area, are shown in table 5. The coastal area is mostly within 6 miles of the ocean. The intermediate area is 7 to 30 miles inland. The interior area is situated between the intermediate area and the mountains, about 50 miles from the coast. The desert and San Joaquin Valley areas are protected from ocean influences by mountains.

The melon aphid was present in much higher populations in the intermediate area than in the others. The most rapid spread of quick decline has been noted in a part of this area. The disease has only recently appeared in another part of this intermediate area. Quick decline has spread slowly in the interior area and has not appeared in the desert or San Joaquin Valley areas.

The melon aphid on citrus is almost

Table 5.—Estimated aphid populations on citrus trees in various southern California areas in the spring of 1950.

APHID SPECIES	PER CENT POPULATION IN GIVEN AREA				
	Coastal	Intermediate	Interior	Desert	San Joaquin Valley
Aphis gossypii Glover	6.3	13.6	3.5	0.0	0.5
Aphis spiraecola Patch	58.3	78.4	80.7	0.0	0.0
Aphis medicaginis Koch	0.1	0.8	2.3	70.7	94.7
Myzus persicae (Sulz.)	4.3	2.6	11.7	29.3	1.2
Macrosiphum solanifolii (Ashmead)	0.0	0.2	1.7	0.0	3.4
Myzus convolvuli (Kltb.)	0.0	0.04	0.1	0.0	0.1
Toxoptera aurantii (Fonsc.)	28.0	4.4	0.02	0.0	0.0
Aphis helianthi Monell	3.1	0.0	0.0	0.0	0.0
Total aphids per tree[1]	7,085	61,110	11,570	11,960	6,890
A. gossypii per tree[1]	442	8,287	409	0	39

[1] At 6,500 twigs per tree.

always in the dark phase, the large apterae being dark gray to almost black. By casual observers this aphid may be confused with *Toxoptera aurantii* (Fonsc.), *Aphis medicaginis* Koch, or *Aphis fabae* Scolopi, which also breed on citrus. The apterae of the green citrus aphid, *Aphis spiraecola*, are apple green. In California aphids infest only the immature leaves, twigs, and buds of citrus trees. They are unable to maintain themselves on mature leaves. This feeding habit results in heavy aphid populations at the time of the spring growth flush, with scattered colonies appearing on succeeding, minor growth flushes in August and later. Parasites and predators of these aphids are more effective in the summer and fall than in the spring.

DISCUSSION.—The situation as it now appears is quite reasonable. The melon aphid is an inefficient vector of citrus quick-decline virus. It occurs in rather large numbers on citrus, particularly in those areas in which the disease has spread rapidly. Our method of sampling citrus aphid populations did not give information on the most important item, namely, the number of melon aphids flying to a citrus tree from other citrus trees. Still, it did indicate populations so high that if the melon aphid had been an efficient vector the spread should have been much more rapid than it has been. The efficiency of the melon aphis as a vector may be decreased by the fact that it is attracted to many plants besides citrus.

If the observations of aphid populations reported in this paper are confirmed, they would indicate that the citrus quick-decline disease will spread rather slowly in the more inland citrus-growing districts of California.

Bennett & Costa (1949) tested the melon aphid as a vector of tristeza virus but did not obtain transmission. It may be that, because of the small number of tests made (15 transmission tests using 100 to 300 insects in each), they simply failed, by chance, to obtain transmission with an inefficient vector. If that is the case, the quick-decline (or tristeza) virus was probably introduced into Califronia shortly before it was noticed. If the melon aphid does not transmit the tristeza virus, it is possible that, because of the absence of a suitable vector, this virus has been present in the United States for a great many years without being discovered. This tristeza virus could have mutated some time in the 1930's to produce a virus that could be carried by the melon aphid and cause the appearance of the quick-decline disease. If this virus has mutated once, it could do so again in other localities and result in a virus strain transmissible by still other insect species.

SUMMARY.—The virus of citrus quick decline has been transmitted by the melon aphid, *Aphis gossypii* Glover. Under experimental conditions this aphid has been found to be a rather inefficient vector. Surveys of the aphids breeding on citrus in California in 1950 showed high populations of melon aphid in certain areas in southern California in which the disease has spread rapidly, and generally low populations in areas in which the disease has spread slowly. None of the other 311 species of insects tested has transmitted the disease, with the possible exception of certain membracids, about which the evidence is inconclusive.

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The Inhibition of Cholinesterase in the American Roach by Organic Insecticides and Related Phosphorus-Containing Compounds[1]

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The discovery that the effects of the insecticide parathion (Schrader 1947) are due chiefly to the anticholinesterase activity of alkyl polyphosphates (Chadwick & Hill, 1947; DuBois & Mangum, 1947) has led to intensive study of the cholinesterase enzymes of insects and their behavior in the presence of various insecticides, especially those containing organic compounds of phosphorus. Detailed investigations with parathion and related compounds have shown the effects of these mono-phosphorus materials also to be related to inactivation of the cholinesterase of the central nervous system in the housefly and the honeybee (Metcalf & March 1949, 1950), though the quantitative correlation between the dosages for 50 per cent mortality (LD 50) and concentrations for 50 per cent enzyme inhibition (IN 50) *in vitro* is low. The observations with the American roach that the toxicities of parathion and of its oxygen analog, paraoxon, are nearly the same but the onset of symptoms of toxic action occurs much more rapidly with the latter compound, have suggested that a study of the cholinesterase system in the roach and its sensitivity to organic phosphorus compounds might throw light upon the more detailed features of their toxic effects.

Methods and Materials.—The insects used were adult American roaches, *Periplaneta americana*. Except in a few comparative tests as noted later, all were males. They were reared in the laboratory in large glass jars containing a layer of slightly moist sand and about 2 inches of excelsior. Puppy food meal and water were present at all times. Several hundred individuals of various ages were in a colony and the age as adults of those selected for use was not known precisely but was between two weeks and a few months.

Chemicals were applied to the living roaches in two ways: first, by topical application in water or organic solvent, *e.g.*, alcohol, to the dorsal abdominal surface beneath the wings and, secondly, by injection of an aqueous solution, or an alcohol or acetone solution previously diluted at least 50 to 1 with water, between the fourth and fifth abdominal sternites about half way between the center of the venter and the left side of the insect. The needle was inserted one quarter inch and at an angle of about 20° from the surface. The injector resembled the microtitrator described by Woodrow (1949) but had a sixteenth-inch drill rod plunger activated by a commercial micrometer head and a fine tipped glass needle. The dimensions of the plunger and micrometer allowed 0.0001 ml. to be measured with considerable accuracy and since the usual volume injected was 0.005 ml. the error involved was negligible. Observations were made at intervals following injection to determine the onset and development of symptoms of toxic action.

In preparation for determination of cholinesterase (ChE) activity, a selected roach, normal or previously treated as desired, was opened along the ventral surface and the central nerve cord including all abdominal ganglia and the meso-and metathoracic ganglia carefully freed from all adhering connective or fatty tissue. It was pulled out, rinsed and excess water removed with filter paper. The moist cord was weighed quickly to 0.1 mg. on a microbalance and then ground for 1 minute in two drops of distilled water in a micro Potter-Elvehjem (1936) homogenizer. The finely ground suspension was then diluted with water to give 2.00 mg. cord per ml. Portions of this brei were used in determinations of ChE activity.

Cholinesterase activity was measured by titration of the acetic acid liberated from acetyl choline (AcCh) added as the bromide salt to the brei, according to the general procedure of Stedman *et al.* (1933). The reaction was carried out in small

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test tubes, 0.9 cm. in diameter and of 1.5 ml. volume. The order of addition of materials was: 0.05 ml. 0.04 per cent bromthymol blue indicator solution, 0.45 ml. water, 0.05 ml. 5 per cent AcCh solution, necessary 0.02N alkali to approximately neutralize, 0.1 ml. nerve cord brei, water to bring to 1.0 ml. and just before starting a run, the very small amount of 0.02 N alkali to precisely adjust to pH 7.4. If a poison was to be used, it preceded the final adjustment of volume. This order of addition ensured that the enzyme in the brei was never exposed to a harmful pH nor to abnormal concentration of substrate or poison. The final concentrations of the various materials in the tube were: indicator 0.02 per cent, AcCh substrate 0.25 per cent or 0.011 M, brei 0.2 mg./ml. and anticholinesterase insecticide as desired. These amounts and concentrations were chosen as the result of preliminary tests to determine the optimum conditions for accuracy both of weights and volumes and for multiple runs on brei from a single cord in order to minimize the effects of natural variation in activity. The concentration of the AcCh substrate proved later to be above that for maximum activity of the enzyme but this condition was outweighed by the advantage of sufficient excess to hold the concentration practically constant during the most active run, as shown by data cited later. In some runs Yeager's (1939) saline solution designed for work with the American roach was used instead of water in bringing the reaction mixture to volume, but it appeared not to alter the results obtained with distilled water.

Stirring proved to be very important and was accomplished with a fine glass rod attached to the arm of an ordinary door buzzer. Except as noted in the description of the various experiments, the reaction was allowed to run for one hour at which time the pH was restored to 7.4 by titration with the standard 0.02 N alkali solution. This was repeated at hourly intervals up to four hours and longer in some special cases. The total volume of alkali needed never exceeded 0.15 ml. and usually was much less, so the change in concentration of the brei and of the poison in the reaction tube did not change appreciably. The burette for delivering alkali was a capillary tube about one third mm. in diameter. A seven cm. length was calibrated for variations in bore and fitted with a scale marked at 0.175 mm. distances, corresponding to about 0.01 mm.[3] The tube was drawn to a long fine point at the lower end and discharge of liquid was controlled by compression of a stiff rubber tube on the upper end by means of a fine thread screw clamp.

The titrations with very rare exceptions appeared to be satisfactorily sharp, but in some cases obviously discordant values were obtained for two successive endpoints, *i.e.*, an unusually large volume would be succeeded by a very small one and vice versa. In such cases the best average line was drawn through all titration values and these adjusted volumes used in calculating amounts of liberated acid.

During the course of the hour interval between titrations the pH decreased as shown by change of the indicator from strong blue to light blue or light yellow. The indicator color showed the pH seldom to drop below pH 6. Cholinesterases of various tissues change in activity as the pH changes but Babers and Pratt (1950) showed the ChE from housefly heads to be reasonably constant in activity over the pH range concerned, with a moderate maximum near pH 6. All runs were made at laboratory temperature which was roughly controlled to stay between 25 and 27° C.

The acid which accumulated in the reaction vessel between titrations did not necessarily measure only the splitting of AcCh by cholinesterase, for processes within the brei might form either acids or bases and the AcCh might hydrolyze spontaneously. To allow for these processes the following preparations were run together with that previously described: I, indicator only; II indicator plus brei; III, indicator plus AcCh; IV, indicator plus AcCh plus brei (uninhibited activity) and V, indicator plus AcCh plus brei plus poison (inhibited activity). All components were at the usual concentrations. Hence, II–I gives activity of brei with whatever AcCh is naturally in it plus any other acid or base production (N); IV–III gives activity with added AcCh minus apparent activity due to changes in the AcCh (NA); and V-III gives activity with added AcCh in presence of poison minus apparent activity of AcCh

(P). Therefore, net uninhibited activity is NA−N, net inhibited activity is P−N and relative inhibited activity is (P−N)/(NA−N) or relative reduction in activity in presence of a poison is 1−(P−N)/(NA−N)=NA−N−(P−N)/(NA−N), from which the percentage reduction equals (NA−N)/(NA−P)×100.

Any hydrolysis of the insecticide during a run would also add acid or base to the system. There seemed to be no simple method for measuring this effect and it would necessarily be small because of the low concentrations used. In each run the various systems were repeated from two to five times in order to obtain average values of higher accuracy. In the determination of *in vitro* inhibition, several portions of the untreated brei were always used to determine NA. This provided a truer basis of reference than the average NA value from many cords which had to be used for *in vivo* inhibition.

The chemicals which were tested for toxicity and anticholinesterase effect are listed in table 1, together with their formulas, molecular weight and physical states. Several samples of parathion from a number of manufacturers were used. These differed greatly in color but were indistinguishable with respect to toxicity and anti-ChE activity with the exception that a sample that stood in a bottle in the laboratory for approximately a year was less active in both properties. The reduced parathion was made in the laboratory especially for this work. Several samples of tetraethyl pyrophosphate were compared with only minor differences becoming apparent. The other chemicals were all furnished from the research laboratories of several insecticide manufacturers by courtesy of the directors. They were of 95 per cent or higher purity by elementary analysis but some contained enough impurities to affect the color markedly. In preparing the various dilutions the chemicals were taken as pure and concentrations were calculated on a weight-volume basis. This was convenient at the time but led to somewhat awkward relations when expressed in molality. All materials were put into solution shortly before use and held over at a low temperature. When necessary, alcohol or acetone was used as the solvent to prepare a one per cent solution which was diluted 50-fold or greater with water just before use. Such dilute solutions were not kept over.

RESULTS.—*Some properties of cholinesterase from the ventral nerve cord of American roaches.*

In order to study the effect of chemicals upon the ChE activity in the nerve cord of roaches it was necessary to determine the normal activity of cords from untreated individuals when tested as a brei under the conditions established as standard. Several dozen runs made with 35 different cords over a period of several months gave a grand average NA value of 0.701 micromols AcCh split per mg. of tissue per hour. Upward and downward trends in equal numbers and amounting to several per cent were shown in some of the individual runs over a 4 to 6-hour period but the average showed no change. The different cord breis varied considerably, average rates of substrate splitting ranging from 0.553 to 1.01 micromols. These differences may be due in part to unrecognized differences in preparing the breis but probably are mostly due to real differences in enzyme content of the various cords. Since brei from the same cord was used as a standard whenever possible, this variation had little importance in most cases.

As explained in the section on methods, the various tissue breis produce acid in the absence of added AcCh, as shown by the N values. This may occur at the expense of AcCh present in the cord when it was removed from the body, or other enzymes may be producing acids from other substrates, or nonenzymatic processes may be responsible. Two observations indicate that the first interpretation probably is incorrect; a) when large amounts of inhibitor are used the activity does not reach zero but tends to remain at 0.02 to 0.03 micromols/mg./hr. and b) the N values for cords soaked for long periods in saline are not decreased as would follow if a soluble substrate such as AcCh were responsible for most of the reaction. It would be more accurate then to express ChE activity for the various tissues as NA−N. Tests with 25 cords from unpoisoned roaches gave an average value for N of 0.022 micromols/mg./hr. with range from 0.0035 to 0.053. Hence the corrected value (NA−N) for the average activity of normal male roach nerve cord brei is 0.701−0.022 or 0.679 micromols

Table 1.—Name, formula and physical state of compounds used.

I.	triethyl phosphate $(C_2H_5O)_3PO$ m.w. 182	colorless liquid
II.	triethyl thiophosphate $(C_2H_5O)_3PS$ m.w. 198	brownish liquid
III.	diethyl monosodium phosphate $(C_2H_5O)_2P(O)ONa$ m.w. 176	light yellow solid
IV.	diethyl chlorophosphate $(C_2H_5O)_2P(O)Cl$ m.w. 172.5	light yellow liquid
V.	di*iso*propyl chlorophosphate $\left\{\begin{matrix}CH_3\\CH_3\end{matrix}\right\rangle CHO\Big\}_2 P(O)Cl$ m.w. 200.5	brownish liquid
VI.	diethyl thio chlorophosphate $(C_2H_5O)_2P(S)Cl$ m.w. 188.5	dark brown liquid
VII.	ethyl thio dichlorophosphate $(C_2H_5O)P(S)Cl_2$ m.w. 179	brown liquid
VIII.	tetraethyl pyrophosphate $(C_2H_5O)_2P(O)OP(O)(OC_2H_5)_2$ m.w. 290	colorless liquid
VIIIa.	tetraethyl dithio pyrophosphate $(C_2H_5O)_2P(S)OP(S)(OC_2H_5)_2$ m.w. 322	light yellow liquid
IX.	diethyl *p*-nitro phenyl phosphate $(C_2H_5O)_2P(O)OC_6H_4NO_2$ (paraoxon) m.w. 261	brown liquid
X.	diethyl *p*-nitro phenyl thiophosphate $(C_2H_5O)_2P(S)OC_6H_4NO_2$ (parathion) m.w. 277	brown liquid repurified sample colorless
XI.	diethyl *p*-amino phenyl thiophosphate hydrochloride $(C_2H_5O)_2P(S)OC_6H_4NH_2 \cdot HCl$ m.w. 283.5	tan solid
XII.	diethyl *p*-methoxy phenyl phosphate $(C_2H_5O)_2P(O)OC_6H_4OCH_3$ m.w. 260	light orange liquid
XIII.	diethyl-*p*-nitro, benzyl phosphonate $(C_2H_5O)_2P(O)CH_2C_6H_4NO_2$ m.w. 273	dark brown liquid
XIV.	diethyl-*p*-chlorobenzyl phosphonate $(C_2H_5O)_2POCH_2C_6H_4Cl$ m.w. 262.5	light yellow liquid
XV.	diethyl anilido phosphate $(C_2H_5O)_2P(O)NHC_6H_5$ m.w. 224	white solid
XVI.	di*iso*propyl anilido phosphate $\left\{\begin{matrix}CH_3\\CH_3\end{matrix}\right\rangle CHO\Big\}_2 P(O)NHC_6H_5$ m.w. 256	white solid
XVII.	*p*-nitro phenyl disodium phosphate $(NaO)_2P(O)OC_6H_4NO_2$ m.w. 290	yellow solid
XVIII.	di(*p*-nitro phenyl)-*p* chlorobenzyl phosphonate) $(NO_2C_6H_4O)_2PCH_2C_6H_4Cl$ m.w. 356.5	brown liquid

/mg./hr. The inaccuracy in the value of N is involved, of course in this figure. The correction is automatically made in calculating per cent inhibition in presence of a poison.

The agreement between repeated tests with brei from the same nerve cord was close in nearly all cases. In 26 runs made with breis from eight cords, the average activity was .705 micromols AcCh split per mg. tissue per hour. The deviations of the separate runs from the average activity of the cord concerned ranged from 0 to 12 per cent and averaged 4.3 per cent. Calculated as standard error this amounted to 0.042 micromols AcCh/mg./hr.

While the enzyme ChE is not limited

to nervous tissue, the amounts in other tissues frequently are small and sometimes have different characteristics (Augustinsohn, 1948; Koelle & Gilman, 1949). A limited number of tests with roach tissues gave the following activities (NA), all in micromols AcCh split/mg./hr.: fat body 0.017, muscle 0.015, testes 0.019. These values have not been checked in numerous tests but they obviously indicate the low activity of the tissues. The corresponding values of N for these tissues are: fat body 0.008, muscle 0.006, testis 0.006. Hence their corrected activities (NA−N) are 0.009, 0.009 and 0.013 micromols/mg./hr., respectively.

A few tests with female roaches showed that the ChE of breis from the nerve cord was about 60 per cent as active as in case of the males used in all other cases. This sexual difference is similar to that found by Babers & Pratt (1950) with houseflies. These manifest no sexual difference in ChE activity when freshly emerged but the males show almost twice the activity of females after a few days. A similar situation in rooster and hen blood plasma appears to be related to activity of sexual hormones (Caridriot *et al.*, 1948). Male rats are more resistant to the ChE-inhibiting compound parathion than females but the relation, if any, of sexual differences in ChE activity to sexual differences in susceptibility to ChE inhibitors apparently has not been studied in any species.

It has been pointed out by Means (1942) and by Richards & Cutkomp (1945) that the ganglia of the central nerve cord in grasshoppers and roaches are richer in ChE than the connective tissue between them. Consequently, differences might be expected between the thoracic and the abdominal portions of the nerve cord in roaches since the former portion has much more prominent ganglia. A few tests indicated the correctness of this hypothesis since the thoracic portion had an average activity of 0.765 and the abdominal portion 0.432 micromols/mg./hr. As might be expected, the average overall activity lies between these figures.

The true or specific ChE of the central nervous system of various organisms is inhibited by excess AcCh (Augustinsohn, 1948) and hence a plot of activity versus concentration of substrate, usually expressed in log of concentration for convenience, is bell-shaped. This relation holds for brain ChE of the housefly and the honeybee (Metcalf & March, 1950). Nerve cord brei from roaches tested in the usual way but with increasing concentrations of AcCh had the following activities during the first hour when expressed as micromols split per mg. tissue per hour: 0.05 per cent AcCh, 0.828; 0.10 per cent, 1.138; 0.25 per cent, 0.878; 0.50 per cent, 0.828; 1.00 per cent 0.748. A plot of activities versus log concentration AcCh gives a fairly symmetrical curve with maximum at about 0.11 per cent or 0.005 M. It is probably of no significance that the breis used in this test were somewhat more than usually active.

Toxicity and inhibition in vivo.—Mention was made previously that no detectable change in activity of ChE in nerve cord breis from normal roaches occurred during a few hours' action upon added AcCh. This was also the case with breis from roaches injected with various chemicals and dissected at intervals thereafter. Hence the average activities could be used as a measure of the inhibition of the enzyme occurring *in vivo*. The average values of NA (0.701) and of N (0.022 micromols/mg./hr.) were used in calculating per cent inhibition since it was not possible to use portions of the brei for determining N and NA.

In table 2 are collected the data on visible evidence of toxic action and on the extent of inhibition of nerve cord ChE in roaches following injection of eighteen chemicals. The individual figures are average of two to ten separate determinations. The arrangement is based upon triethyl phosphate as the starting structure from which the various compounds may be considered to be derived by increasingly extensive changes. While arbitrary, this arrangement is useful in bringing the most active materials together in the middle of the table. It is obvious that all the compounds of marked toxicity are strong inhibitors of ChE at moderate dosages. Conversely, those materials which at 50 micrograms/gram dosage cause no toxic symptoms, do not cause over about 50 per cent ChE inhibition. An outstanding point is that these materials which are toxic rapidly also inhibit ChE activity in a short time and the slowly toxic ones, such as parathion,

also inhibit slowly. The two tests with topically applied parathion show that it is absorbed very rapidly from the back of the thorax and base of the wings since both toxicity and enzyme inhibition are comparable to those resulting from injection. The marked differences in absorption of DDT and other insecticides from various parts of the body of grasshoppers (Kennedy *et al.*, 1948) suggest similar differences with the roach. Prostration from parathion is accompanied by decrease in the volume of blood obtainable from the roach, as was noted by Roan *et al.* (1950) in case of TEPP poisoning.

Inhibition in vitro.—Determination of ChE inhibition *in vivo* is undoubtedly preferable to any *in vitro* procedure when the relation to toxic action is concerned but because of its convenience and the opportunity to use a portion of the tissue as its own normal, the *in vitro* method has been used widely (Brauer 1948; Chadwick & Hill 1947, Metcalf & March 1949, 1950). Table 3 contains data for the *in vitro* inhibition of ChE in breis from the ventral nerve cord of male American roaches by all chemicals included in table 1 plus the dithio analog of tetraethyl pyrophosphate. In addition, the following compounds at stated concentrations had no inhibitory effect under the same conditions: Nicotine (0.01 per cent, pyrethrins (0.001 per cent), γ-benzene hexachloride (0.001 per cent), and piperonyl cyclonene (0.003 per cent).

An interesting feature in table 3 is the increase in inhibition of ChE activity occurring after the first reading at 1 hour. This is the case with all active compounds at the higher concentrations, except reduced parathion, though sometimes inhibition from the lower concentrations showed no change. Consequently, the usual method of determining inhibition by comparison of normal and poisoned tissues for a few minutes (Augustinsohn, 1948) or even for an hour (Chadwick and Hill, 1947) immediately after mixing will be valid for comparison with toxic symptoms only when these appear rapidly.

To examine this matter further, the inhibition from 7.7×10^{-6}M paraoxon was measured at shorter intervals with the

Table 2.—Toxicity by injection and ChE inhibition *in vivo*.

Compound	Amount Injected in γ/Gm.	Final Mortality in %	LD 50 γ/gm.	LD 50 Micromols./gm.	Average Time in Hours to Symptoms (to Death)	Time in Hours to Dissection	Symptoms Just Before Dissection	ChE Activity in γ Mol./Mg./Hr.	Inhibition in %
I. triethyl phosphate	50	0	>>50	>>0.274	a[1]	8	a	0.439	38
II. triethyl thiophosphate	15	50	15	0.076	1.5 (50)				
	20	87			1 (40)				
	30					1	d	0.038	98
	50	100			14 min. (23)				
III. diethyl mono sodium phosphate	50	0	>>50	>>0.320	a				
IV. diethyl chlorophosphate	30	0	33.5	0.194	a				
	33	44			10 min. (26)				
	35	83			5 min. (18)				
	40	100				0:20	d	0.033	99
V. di*iso*propyl chlorophosphate	50	0	>>50	>>0.750	a				
VI. diethyl thio chlorophosphate	10	0	19	0.101	a				
	15	14			7 (50)				
	20	60			6				
	30	100			4	2	a	0.570	19
						3	d	0.037	98
	50	100			2				
VII. ethyl thio dichloro phosphate	50	0	>>50	>>0.750	a				
VIII. tetraethyl pyrophosphate	1.0	0	3.0	0.010					
	2.0	0			30 min.[2]				
	3.0	50			12 min. (23)				
	3.3	87			12 min.				
	1.6	0			30 min.	0:15	b	0.134	85
						1	d	0.149	82
						1:40	c	0.184	76
						7:30	a	0.274	63
						24	a	0.463	35

Table 2—*continued.*

Compound	Amount Injected in γ/Gm.	Final Mortality in %	LD 50 γ/gm.	LD 50 Micromols./gm.	Average Time in Hours to Symptoms (to Death)	Time in Hours to Dissection	Symptoms Just Before Dissection	ChE Activity in γ Mol./Mg./Hr.	Inhibition in %
IX. diethyl *p*-nitrophenyl phosphate	0.6	0	0.70	0.0027					
	0.66	25			25 min. (18)				
	0.7	50			15 min.				
	0.75	83			13 min.				
	1.0	100			10 min.	0:30	e	0.025	99
X. diethyl *p*-nitrophenyl thiophosphate	0.6	0	0.72	0.0026					
	0.7	37			7 (36)				
	0.8	87			7 (24)	12	e	0.025	99
						20	f	0.013	100
	1.0	100			6 (21)	1:30	a	0.447	38
						3	a	0.342	53
						4:30	d	0.038	98
						16	f	0	100
	2.0	100			3				
	3.0	100			3	1	a	0.550	23
						3:45	b	0.118	86
						4	e	0.032	99
	2.0[3]	100			2	3	e	0.059	95
	3.0[3]	100			1.5	3	e	0.049	96
XI. diethyl *p*-aminophenyl thiophosphate. HCl	4.0	0	8.0	0.028					
	7.0	25			6 (45)				
	8.0	50			6 (45)				
	10.0	100			5 (42)				
	30.0	100			3.5 (24)	2	a	0.552	22
						4	d	0.031	99
XII. diethyl *p*-methoxyphenyl phosphate	33	0	>>33	>>0.127	a				
XIII. diethyl *p*-nitro tolyl phosphate	50	0	>>50	>>0.180	a	9	a	0.329	55
XIV. diethyl *p*-chloro tolyl phosphonate	50	0	>>50	>>0.190	a				
XV. diethyl anilido phosphate	50	0	>>50	>>0.220	a				
XVI. diisopropyl anilido phosphate	50	0	>>50	>>0.195	a	9	a	0.356	51
XVII. di sodium *p*-nitrophenyl phosphate	50	0	>>50	>>0.172					
XVIII. di (p-nitrophenyl)-*p*-chlorotolyl phosphonate	50	0	>>50	>>0.140	a				

[1] Symptoms of toxicity as observed in the roach:
a. none.
b. hyperactive.
c. vibrates body when prodded.
d. vibrates body spontaneously, sometimes runs about wildly.
e. partly paralyzed.
f. almost totally paralyzed, often lies on back.
[2] Minor symptoms in some individuals, but all recovered.
[3] Applied topically in 10 per cent ethanol.

following results: 5 minutes, 0 per cent; 10 minutes, 47 per cent; 23 minutes, 80 per cent; 60 minutes, 82 per cent. Another run gave: 5 minutes, 0 per cent; 20 minutes, 79 per cent; 40 minutes, 87 per cent. These data indicate the advantage of a period of adjustment before measurements are started as recommended by Metcalf and March (1949). Since in the present work, two to four dozen runs were carried out simultaneously, there was necessarily a period of several minutes between the addition of all ingredients and the final adjustment of pH before readings started.

It was of interest to determine how far the increase in inhibition would proceed if the runs were continued longer. Inhibition from the rapidly acting TEPP at 0.7×10^{-6}M increased from 62 per cent at 4 hours to 68 per cent at 6 hours and that from the slowly acting parathion at 0.7×10^{-4}M from 28 per cent at 4 hours to 31 per cent at 6 hours and 37 per cent at 8 hours. It should be mentioned that this concentration is approximately the solubility of parathion in water and hence its effect should reach a maximum at this point. As shown in table 3, there is no change when the concentration is

Table 3.—Inhibition in vitro of ChE in ventral nerve cord of male roaches.

Chemical	Concentration Molal	Per Cent Inhibition 1	2	3	4 Hrs.	IN 50 in Vitro 1 Hr.	4 Hrs.
I. triethyl phosphate	4.4×10^{-4}	36	38	41	45	5.5×10^{-4} [1]	5.0×10^{-4} [1]
	2.2×10^{-4}	8	0	11	12		
II. triethyl thio phosphate	1×10^{-4}	68	77	88	100	6×10^{-5}	4.5×10^{-5}
	0.5×10^{-4}	34	52	63	77		
	0.25×10^{-4}	34	44	56	71		
III. diethyl sodium phosphate	2.3×10^{-4}	0	0	0	0		
	0.6×10^{-4}	0	0	0	0		
IV. diethyl chloro phosphate	6×10^{-5}	85	88	93	94	2×10^{-6}	2×10^{-6}
	3×10^{-5}	91	90	88	85		
	1.5×10^{-5}	85	77	76	75		
V. di*iso*propyl chlorophosphate	2×10^{-4}	0	0	0	0		
	0.5×10^{-4}	0	0	0	0		
VI. diethyl thio chlorophosphate	1.1×10^{-4}	43	44	57	68	1.6×10^{-4} [1]	0.5×10^{-4}
	0.5×10^{-4}	33	38	44	47		
	0.25×10^{-4}	21	20	29	41		
VII. ethyl thio dichlorophosphate	2.3×10^{-4}	0	0	0	0		
	0.6×10^{-4}	0	0	0	0		
VIII. tetraethyl pyrophosphate	1.4×10^{-6}	45	57	67	79	1.8×10^{-6} [1]	0.4×10^{-6}
	0.7×10^{-6}	25	47	56	62		
	0.35×10^{-6}	32	38	43	47		
	0.17×10^{-6}	5	10	15	25		
VIIIa. tetraethyl dithio pyrophosphate	0.8×10^{-4}	77	92	100	100	6×10^{-5}	6×10^{-5}
	1.6×10^{-5}	67	68	68	67		
	0.8×10^{-5}	41	43	43	41		
IX. diethyl *p*-nitro phenyl phosphate (paraoxon)	7.7×10^{-6}	82	92	97	100	1.9×10^{-6}	0.6×10^{-6}
	3.8×10^{-6}	68	83	92	100		
	1.9×10^{-6}	51	64	68	72		
	0.8×10^{-6}	25	38	49	58		
X. diethyl *p*-nitro phenyl thiophosphate (parathion)	1.5×10^{-4}	14	18	23	32	[2]	5×10^{-4} [1]
	0.7×10^{-4}	11	19	26	28		
	0.35×10^{-4}	8	14	16	18		
	0.07×10^{-4}	0	4	4	4		
XI. diethyl *p*-amino phenyl thiophosphate · HCL	8.8×10^{-5}	46	42	38	33	2×10^{-4} [1]	2×10^{-3} [1]
	1.8×10^{-5}	38	35	33	31		
	0.7×10^{-5}	36	38	41	38		
	0.4×10^{-5}	33	31	27	19		
XII. diethyl *p*-methoxy phenyl phosphate	1.5×10^{-4}	0	0	0	0		
	0.4×10^{-4}	0	0	0	0		
XIII. diethyl *p*-nitro benzyl phosphonate	1.5×10^{-4}	0	0	0	0		
	0.4×10^{-4}	0	2	2	2		
XIV. diethyl *p*-chloro benzyl phosphonate	1.5×10^{-4}	0	0	0	0		
	0.4×10^{-4}	0	0	0	0		
XV. diethyl anilido phosphonate	1.8×10^{-4}	0	0	0	0		
	0.45×10^{-4}	0	0	0	0		
XVI. di*iso*propyl anilido phosphonate	1.6×10^{-4}	0	0	0	0		
	0.4×10^{-4}	0	0	0	0		
XVII. *p*-nitrophenyl disodium phosphate	1.4×10^{-4}	10	14	17	14		
	0.7×10^{-4}	0	6	11	16		
	0.35×10^{-4}	13	14	16	14		
XVIII. di(*p*-nitro phenyl) *p* chlorobenzyl phosphate	1.1×10^{-4}	0	0	0	0		
	0.3×10^{-4}	0	0	0	0		

[1] Values obtained by upward extrapolation.

[2] Extrapolated value exceeds solubility.

doubled. The compound *p*-nitrophenyl disodium phosphate (XVII) gave erratic results, possibly from hydrolysis. The data in table 3 are averages of several runs and agree in showing that it causes but slight decrease in ChE activity.

The outstanding feature of table 3 is the failure of parathion to show high inhibition of ChE activity *in vitro* even at concentrations a hundred fold greater than needed with paraoxon for complete inhibition. Since these compounds are of almost equal toxicity when injected or applied topically, this result indicates the inadequacy of *in vitro* tests with parathion and poses the problem of why this compound behaves so differently *in vivo* and *in vitro*. From the fact that ChE inhibition increases fairly rapidly following injection of parathion (Table 2) it seemed possible that the compound undergoes some change to a more active form. Experiments were therefore undertaken to test this hypothesis.

Incubation of parathion with insect blood, muscle, fat body, digestive tract, malpighian tubules or integument, either intact or as breis, for several hours did not cause it to be more active in inhibiting nerve cord ChE in subsequent *in vitro* tests with normal nerve cord breis. Parathion at 0.7×10^{-4}M plus nerve cord brei (0.8 mg./cc.) were left together for 1 hour; then AcCh was added and the mixture diluted four fold, *i.e.*, the parathion concentration became 0.17×10^{-4}M. The activity compared with a portion of the same brei was inhibited to the following extent: 1 hour, 49 per cent; 4 hours, 53 per cent. Similar inhibitions resulted from 3 hours exposure of brei to parathion. At this concentration parathion caused less than 30 per cent inhibition when used with nerve cord brei with AcCh present at all times in the usual procedure (Table 3).

If this increase in inhibition was due to an activation of parathion, it was possible that enhanced toxicity might follow injection of such a preparation. Hence the following experiment was performed. Nerve cord brei at 1 mg./cc. was exposed to parathion at 3.5×10^{-4}M. After the suspension had stood for 1:20, 3:30 and 5 hours it was injected into normal roaches at the rate of 10 mm.^{3}, or 1γ parathion/gm. body weight. This dose usually causes 100 per cent mortality. In the test, two out of three roaches died

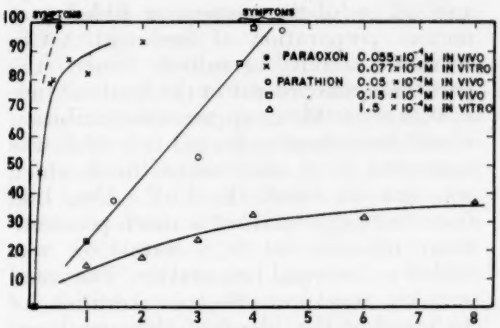

FIG. 1—Per cent inhibition of cockroach cholinesterase at various periods following *in vivo* and *in vitro* exposure to parathion and paraoxan. Time in hours

and symptoms appeared at the usual times. Hence there was no evidence of enhanced activity from the exposure of parathion to nerve cord brei.

The high inhibition occurring *in vivo* after injection of parathion may be duplicated *in vitro* by exposing whole nerve cords to parathion in saline solutions as shown by the following experiments. Exposure to 0.087×10^{-4}M parathion for two hours, followed by washing, grinding and testing in the usual manner resulted in 90 per cent inhibition. Exposure for 6 hours caused almost complete inhibition. Higher concentrations up to saturation had about the same effect. When exposure was prolonged to 18 hours, 0.087×10^{-4}M parathion inhibited activity 100 per cent and 0.044×10^{-4}M parathion inhibited it 75 per cent. In all cases the degree of inhibition changed very slightly if at all during the course of several hours run. Parallel tests with normal cords soaked in saline only for the same periods of time gave the usual activity after 8 hours and a very slight decrease after 18 hours, though they were somewhat more sensitive to parathion. Thus the ChE activity of cords left in saline for 18 hours and then treated as brei with 0.087×10^{-4}M parathion was inhibited 30 per cent. This may be contrasted with negligible inhibition in the case of freshly dissected cords. The change does not seem sufficient to account for the very high inhibition resulting from long exposure to parathion solutions as mentioned above.

It seemed possible that intact nerve cord might have an effect upon parathion not shown by breis and therefore whole nerve cord soaked for 4 hours in 0.7×10^{-4}M parathion in saline was ground

and 0.2 cc. of the suspension added to a normal preparation of brei and AcCh. Normal activity resulted. Since the parathion was present in the final mixture at 0.14×10^{-4}M, an appreciable inhibition would have been expected only if it was converted to a more active form which was free to reach the ChE. Also, brei from the nerve cord of a roach prostrate from injection of 3 γ parathion was added to a normal preparation. The usual activity was not affected. Addition of 10 mm.^{3} of the blood of this paralyzed roach to normal nerve cord brei had no detectable effect upon its activity in the usual test. These results parallel the finding of Chadwick & Hill (1947) with diisopropyl fluorophosphate, which they found to be combined very tightly in the nerve cord of injected roaches.

The reversibility of the action of parathion upon ChE was studied further by removing the nerve cords from two injected roaches after they had become prostrate, which condition in many tests corresponded to a ChE inhibition of 90 per cent or more. One cord was placed in a considerable volume of saline for four hours and then run in the usual manner. The average activity was 0.309 micromols AcCh split/mg./hr., which is equivalent to 58 per cent inhibition. The other cord was washed for 23 hours after which its activity was 0.226 micromols mg./hr., corresponding to an inhibition of 70 per cent. Since the latter insect was given a larger dose the difference is probably to be expected. Evidently washing decreased the inhibition. However, living roaches appear to be unable to overcome the effects of parathion when these reach even the first signs of paralysis and no lessening of the degree of ChE inhibition was found in tests with badly affected insects (Table 2). Tetraethyl pyrophosphate appears to be a somewhat reversible poison. The run with a series of roaches given about half a lethal dose, included in table 2, shows that inhibition fell steadily after the most intense symptoms were past. It is probable, however, that hydrolysis of the tetraethyl pyrophosphate, rather than a splitting of the complex involved in inhibition (Brauer 1948) accounts for this diminution of the effect.

DISCUSSION.—It has been emphasized by Augustinsohn (1948, 1949) that the activity of so called "specific" ChE from nervous tissue, red blood cells and certain other sources is not directly proportional to the concentration of the substrate AcCh. Rather the activity passes through a maximum at a concentration characteristic of the ChE concerned and then decreases, due to inhibitory action of excess substrate. This behavior has been confirmed for ChE from honeybee and housefly brains by Metcalf and March (1950) and for that from male roach ventral nerve cord in the present work.

Table 4.—Comparison of results of several workers on activity of ChE from insect tissues, corrected for non-enzymatic activity.

	Insect Tissue	Method	Concentration AcCh Molal		Concentration of Tissue Brei, Mg./Ml.	Temperature, °C.	Activity in Micromols/Mg./Hr.	Reference
			Used	Optimum				
	American roach ventral nerve cord	Warburg	0.01		3.3	36.7	2.2	Tobias *et al.* (1946)
	American roach ventral nerve cord	Warburg	0.025		5.5	25	0.7–0.8	Richards & Cutkomp (1945)
	American roach ventral nerve cord	Warburg	0.015		0.6 to 5	25	0.84	Chadwick & Hill (1947)
♂	American roach ventral nerve cord	Titration	0.011	0.005	0.2	25–27	0.68	Present work
	Grasshopper ventral nerve cord	Cartesian diver	0.0275		0.07	25	12	Means (1945)
	Grasshopper brain	Cartesian diver	0.0275		0.07	25	22	Means (1945)
	Honey bee brain	Warburg	0.025		5.5	25	1.01	Richards & Cutkomp (1945)
	Honey bee brain	Warburg and titration	0.02	0.01	6.9	37	2.5	Metcalf & March (1950)
♀	Housefly brain	Warburg and titration	0.02	0.01	6.9	37	11.0	Metcalf & March (1950)

Hence comparisons of activities are not on a quantitative basis unless corresponding points of the substrate concentrations-activity curves are used. Various workers have employed such different conditions that a summary may be useful. Table 4 contains the pertinent data.

The optimum AcCh concentrations for the three cases so far studied were each determined at one particular enzyme concentration, which was known only in terms of amount of tissue used. Fortunately, the conditions used caused the activity to differ from that at optimum AcCh concentration by not over 25 per cent. A complete evaluation of the ChE activity would involve not only concentration of substrate and temperature but also concentration of enzyme, treatment of tissue and doubtless numerous other factors. It was noticed in the present work that breis ground less completely than usual always showed less activity and whole cords appeared to hold liberated acid so strongly that they remained yellow from the indicator after the surrounding solution had been neutralized. Chadwick & Hill (1947) reported whole cords to be about half as active as breis by the Warburg technique.

With all these complicating considerations, it is still possible to conclude that agreement among the various workers is excellent and that the temperature coefficient of ChE activity on AcCh is between 2.0 and 2.5 for both roach nerve cord and honeybee brain breis. In comparison with the fly and the bee, the roach is only moderately lively and the ChE activities of the nervous systems of these three insects appear to illustrate the suggestion that more sluggish organisms have less ChE (Lindeman, 1945, Rockstein, 1950). The high values reported for the grasshopper seem out of line, for this insect is no more active than the roach and resembles it sufficiently closely that the two have been classified in the same order by some taxonomists.

The short period used by most investigators has made it impossible to examine effects which come on slowly. Thus the increase in degree of inhibition from 1 to 4 hours could be discovered only by long runs. Such a delay is probably to be expected in a heterogeneous system such as

Table 5.—Comparison of LD 50, IN 50 in vitro and IN 50 in vivo for active compounds, all calculated on molality basis.

Compound	IN 50 In Vitro[1]			IN 50 In Vivo	In x Hours
	LD 50	1 Hour	4 Hours		
I. triethyl phosphate	$\gg 3.9\times10^{-4}$	5.5×10^{-4}	5.0×10^{-4}	$>3.9\times10^{-4}$	8
II. triethyl thiophosphate	1.09	0.6	0.045	<2.3	1
IV. diethyl chlorophosphate	2.77	0.02	0.02	<3.3	0:20
VI. diethyl thio chlorophosphate	1.44	1.6	0.5	<2.3	3
VIII. tetraethyl pyrophosphate	0.14	0.018	0.004	<0.079	0:15
IX. diethyl *p*-nitrophenyl phosphate	0.039	0.019	0.006	<0.055	0:30
X. diethyl *p*-nitrophenyl thiophosphate	0.037		5.0	<0.04 0.05 0.15	12 3 2:30
XI. diethyl *p*-aminophenyl thiophosphate · HCl	0.40	2.0	20.0	<1.5	3:30
XIII. diethyl *p*-nitro tolyl phosphate	$\gg 0.26$			2.6	9
XVI. di*iso*propyl anilido phosphate	$\gg 0.25$			2.8	9

[1] Underlined figures should be used for comparison with other data for each compound.

a suspension of ground tissue but it is not known whether the basic cause is incomplete contact of enzyme and poison due to slowness of diffusion or to a change from a reversible inhibition to an irreversible one such as Grob (1950) found to occur with parathion and ChE of human red blood cells, muscle or brain, or some other cause. Nachmansohn & Feld (1947) reported a delay in the development of inhibition by diisopropyl fluorophosphate and discussed the possible use of extracts rather than suspensions of ground tissue. A few experiments with filtrate from ground nerve cord of roaches indicated that about half the ChE came through a cotton plug but inhibition of such filtrates was not studied.

The chief justification for the use of AcCh above the optimum concentration is that with the ratios of constituents found most suitable, there was no appreciable change in AcCh concentration during a run. Thus one ml. of 0.25 per cent AcCh contains 11 micromols. In an uninhibited run which split 0.7 micromols/mg. tissue/hour on the average, the consumption of AcCh actually was 0.14 micromols/hour since but 0.2 mg. tissue were used. Hence in four hours only 0.56 micromols were consumed or 5.1 per cent of the original substrate. This change would not have an effect detectable with certainty. In the presence of active inhibitors the decrease was much less. The ratios of enzyme and substrate used by many investigators have caused a rapid exhaustion of the latter material and permitted only very short runs (cf Table 4).

Table 3 gives the IN 50 values, *i.e.*, the molar concentrations required to cause 50 per cent inhibition of ChE in the nerve cord brei. The previous remarks concerning the difficulty in comparing activities as determined under one set of experimental conditions with those from other conditions, hold with redoubled force when the more complicated inhibitory process is concerned. In relating these values to toxic effects it probably is logical to use the one hour figures for chemicals which act rapidly and the four hour ones for those which act slowly. Fortunately, all active materials fall into two classes, one causing symptoms in minutes and the other only after some hours.

The amounts of the various chemicals causing inhibition of ChE activity in the living insect may be expressed in terms of micrograms or micromols per gram of body weight as given in table 2, but for comparison with in vitro values in IN 50 it is convenient to express them in the same terms. Chadwick and Hill (1947) found about 70 per cent of the roach's total weight to be liquid and they converted injected doses to concentrations on this basis.

Table 5 gives IN 50 *in vivo* values from the present work, together with the LD 50 and IN 50 *in vitro* data of tables 2 and 3, all calculated to the same molality basis. For convenience in comparing, they are all expressed as coefficients of 10^{-4}M. The data for IN 50 *in vivo* are very incomplete but it is obvious that there is no inconsistency between the IN 50 values *in vitro* and *in vivo* except with parathion for which there is a hundred fold ratio, and to a lesser extent with reduced parathion. Comparison of LD 50 values shows that all highly toxic compounds cause high *in vivo* inhibition and usually high *in vitro* inhibition but the correlation of toxicity with *in vitro* inhibition, in addition to parathion and its reduced derivative, is not quantitative as illustrated for example by compounds II and IV, VI and XI, or VIII and IX or X. This was the case also with the more extensive data presented in table 4 of Metcalf & March's (1949) report on similar experiments with the honeybee. All these results suggest other effects than ChE inhibition with both insects. With the honeybee also the *in vitro* effect of parathion is much less than its toxicity would suggest.

An examination of table 2 shows that visible signs of toxic action are exhibited by treated roaches only when the *in vivo* inhibition of the activity is approximately 85 per cent or a little lower. This appears to agree with the suggestion of Nachmansohn *et al.*, (1948) that ChE is ordinarily present in nervous tissue in several fold excess of the minimum needed for proper functioning and loss of ChE action is not revealed until the excess is inactivated or destroyed and the critical level passed. The agreement between extent of inhibition of ChE *in vivo* and appearance of symptoms of toxicity and the anomalous behavior *in vitro* are graphically shown for parathion and paraoxon in figure 1.

Grob (1950) has commented on the relative inactivity of parathion *in vitro* as compared with DFP, neostigmine and tetraethyl pyrophosphate. Grob *et al.*, (1950) have suggested that parathion may be hydrolyzed *in vivo* to the more potent paraoxon. The delay in symptoms following injection of octamethyl pyrophosphoramide into dogs has been attributed by DuBois *et al.*, (1950) to conversion of the compound *in vivo* into a ChE inhibitor. If this also occurs in plants it would explain the greater effectiveness of octamethyl phosphoramide as an insecticide after it is absorbed by plants. The experimental results which bear on whether such a change occurs in the roach have been mentioned earlier but may be recapitulated briefly as follows: a) *in vivo*, parathion at 1γ/gram body weight or 5×10^{-6}M in body fluids caused 98 per cent inhibition of ChE after 4.5 hours (Table 2), but *in vitro* 30 times as much or 150×10^{-6}M parathion was required to give only 32 per cent inhibition after 4 hours (Table 3). In contrast, paraoxon at 5×10^{-6}M *in vivo* caused 99 per cent inhibition within thirty minutes and at but slightly higher concentration *in vitro* caused 80 per cent inhibition in 23 minutes. Reduced parathion salt resembles parathion in its relatively low activity *in vitro* but the other compounds all manifest little difference in activity between the two methods of use. b) contact between parathion and a relatively intact nerve cord for a few hours leads to high inhibition at once when the cord is ground and tested in the usual manner. c) no other tissue either intact or as brei affects the activity of parathion when tested subsequently. d) the generally good agreement between IN 50 values *in vivo* and *in vitro* for all compounds except parathion and its reduced salt indicates a uniform distribution of the compounds after injection. The data of Roan *et al.* (1950, Tables 5 and 6) indicate that tetraethyl pyrophosphate also is distributed more or less uniformly in the roach except for the tendency of hydrolytic products to collect in the foregut.

There doubtless are many possible explanations for these observations but perhaps one of the three following is most probable: a) in nerve cord brei, parathion is adsorbed and made inactive by the finely divided fats, proteins or other constituents to a greater extent than occurs in the living body; b) ChE is less accessible to parathion in breis or is better protected by AcCh; c) parathion is changed rather slowly to a more active inhibitor, probably paraoxon since the final toxicity of the two compounds is the same. This suggested change does not result in any activated compounds free in solution and hence must be intimately concerned in the combination of inhibitor with enzyme. Thus the failure to show increased activity after incubation with several body tissues, including nerve cord brei; the lack of inhibitory power of such treated brei and lack of toxicity of blood from a prostrate roach and the inability of brei prepared from a whole nerve cord soaked in parathion solution to affect brei from a normal cord, all may be explained by the firm binding of both parathion and its activated derivative by some body constituent, probably ChE.

The hypothesis of especially great adsorption of parathion and its reduced salt upon some constituent of a brei appears unlikely because these two compounds differ markedly in their chemical properties and several close relatives of parathion show no such adsorption. Grinding of nervous tissue would seem to alter exposure of the ChE to all poisons more or less equally. If the lipoid solubility of parathion plays any role, the substance would be expected to accumulate in the fat body or other lipoid tissues which greatly predominate over the lipoids of the ventral nervous tissue, thereby reducing the activity *in vivo* rather than *in vitro*. Thus the activation theory appears to be the most acceptable explanation of the anomalous behavior of parathion available at present.

This problem could be attacked directly by use of parathion containing radioactive sulfur, for if the compound is changed to paraoxon in the intact nerve cord, inorganic sulfide or possibly some oxidized form would be liberated and could be separated from unchanged parathion by partition between water and organic solvents. This method would avoid the difficulty that the activated derivative of parathion is held too tightly to be detected, provided sulfur is thereby liberated. An attempt was made to detect sulfide ion by use of *p*-amino-dimethyl aniline, but only questionable results

were obtained, since this reagent is scarcely sensitive enough to respond to the amounts that could be formed by even complete change to paraoxon.

All active ChE inhibitors included in the present work contain the grouping:

O (or S)
..
$(RO)_2PX$, in which X may be an O-phenyl group or chlorine. Substitution of N or CH_2 for O in the O-phenyl destroys activity, cf. compounds XIII, XIV, XV, XVI, XVIII. Substitution of S for O on the phosphorus greatly delays onset of toxic symptoms, *e.g.*, parathion vs. paraoxon, (X, IX), diethyl thio chlorophosphate vs. diethyl chlorophosphate (VI, IV) and *in vitro* inhibition is greatly reduced in case of parathion. This substitution reduces toxicity sometimes as in dithio-TEPP (VIIIa), or has no effect as in parathion (X), or increases toxicity as in diethyl thio chlorophosphate (VI), comparison being made in each case to the corresponding oxygen compound. The effect of small changes in a molecule are illustrated by compounds IV, diethyl chlorophosphate and V, di*iso*propyl chlorophosphate, for the former is moderately active both in toxicity and ChE inhibition whereas the latter has no effect. Metcalf & March (1949) found the same relation between parathion and paraoxon and their corresponding di*iso*propyl analogs. The inactivity of di*iso*propyl chlorophosphate is of special interest in comparison with the fluoro analog diisopropyl fluorophosphate which is a powerful toxicant and inhibitor of ChE in the roach (Chadwick & Hill 1947).

Among various workers who have proposed mechanisms by which ChE may be inactivated, Burgen (1949) has suggested that the enzyme reacts with dialkyl phosphate which may be formed by hydrolysis of parathion. However, as the present results show, sodium diethyl phosphate is inactive, but diethyl chlorophosphate and the corresponding thio analog are both active. These compounds are strong phosphorylating agents and are much more likely to react with the enzyme than the ordinary phosphoric acid or its simple salts. These results do not help in interpreting the mechanism of action of parathion, etc., but they indicate that the situation is more complex than is implied in Burgen's suggestion.

Comparison of the data for those compounds which were included in the work of Metcalf and March (1949) and also in the present study *i.e.*, compounds VIII, IX, X and XI, shows that ChE of the honeybee brain is 100 to 500 fold more sensitive than ChE of the roach nerve cord to the first three materials as measured by the IN 50 *in vitro* values. These results indicate that in addition to having comparatively low activity in the absence of inhibitors, roach nerve cord ChE is relatively insensitive to some of the highly potent deactivating chemicals. The slightly higher *in vitro* sensitivity of the roach ChE to reduced parathion, as compared to the bee, indicates some specific effect for which no explanation seems available at present.

SUMMARY.—The activity of the cholinesterase of the ventral nerve cord of adult male American roaches averages 0.679 micromols acetylcholine split per mg. tissue per hour as measured by the rate of formation of acetic acid in the presence of a brei made from the nerve cord, when the substrate concentration is 0.25 per cent. This is higher than the optimum substrate concentration of 0.11 per cent or 0.005 M, but the change in rate is only a few per cent. Activity of the fat body, muscle or testes is approximately 0.01 in the same units.

Eighteen organic compounds of phosphorus were tested for toxicity by injection into the abdomen and for resulting inhibition of nerve cord ChE. Inhibition also was determined in breis of nerve cords removed from normal roaches and exposed to the chemicals. When amounts of injected chemicals are calculated as concentrations in body fluid, there is good agreement between extent of inhibition *in vivo* and *in vitro* except in case of parathion which is much less effective *in vitro*. Toxic effects appear whenever inhibition *in vivo* reaches about 85 per cent. Attempts to increase the *in vitro* effect of parathion failed in presence of insect blood or various body organs and succeeded only when an intact ventral nerve cord was present. The hypothesis is offered that parathion is changed to the more reactive paraoxon whenever it makes contact with an intact nerve cord and thus is more reactive as a ChE inhibitor *in vivo* than *in vitro*.

In vitro inhibition increases rapidly immediately after nerve cord brei and inhibitor are brought together and continues to increase slowly for several hours with most of the compounds studied. Among these, all active compounds contain the group $(RO)_2P(O \text{ or } S)X$, in which R is an alkyl radical, and X may be a phenoxy group or chlorine. No activity was found with three phosphonates and two anilido phosphates tried. The thiophosphates are slower in causing signs of toxic action but not usually less toxic ultimately.

The cholinesterase in the ventral nerve cord of the American roach is less active than that from honeybee brain and also is less sensitive to chemicals which inhibit its activity.[1]

[1] Acknowledgments: Dr. Oliver H. Fullmer assisted in some of the experimental work and Dr. H. T. Gordon made many helpful suggestions regarding organization of this report. This cooperation is appreciated sincerely.

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Tests of Acaricides for Control of the Two-Spotted Spider Mite on Lima Beans on Long Island

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During 1950 tests were made of several newly introduced chemical compounds in emulsions, solutions and powders for the purpose of noting their comparative merits in sprays and dusts for control of insects and spider mite feeding on foliage and pods of lima beans, and also to ascertain their relative safety in regard to plant growth. The results from previous tests on Long Island (Huckett 1948) had indicated that the organophosphorus compounds parathion and hexaethyl tetraphosphate were noteworthy in that as sprays or dusts the treatment was capable of effectively controlling the various common pests attacking lima beans, namely the bean aphid, Mexican bean beetle, two-spotted spider mite, *Tetranychus bimaculatus* Harvey, and had no perceptible adverse influence on plant growth. It was with the object of verifying these results and of comparing the effectiveness of these chemical compounds with acaricides of more recent development that the present series of tests was devised. It was considered of particular importance to ascertain the comparative merits of new compounds that offered a higher degree of safety to the operator and other warm blooded animals than is generally accredited to the properties of parathion and hexaethyl tetraphosphate.

The following materials were selected for trial. Thiophosphates in a wettable powder and in emulsions of 25 per cent[1] and 30 per cent[2,3] toxicant strengths and as proprietary dusts containing 1.5 per cent dimethyl analog of parathion and 1 and 0.5 per cent parathion; tetraethyl pyrophosphate in an emulsion of 20 per cent toxicant strength, and as a proprietary dust containing 1 per cent active ingredient; ethyl *p*-nitrophenyl thionobenzene phosphate[4] in a wettable powder of about 30 per cent toxicant[5] strength; organophosphorus compounds for systemic purposes in water miscible concentrates of 32.1 per cent[6] and 63.3 per cent[7] toxicant strengths; 15 per cent methyl ethyl sulfite wettable powder;[8] a chlorobenzene sulfonate wettable powder of 50 per cent toxicant strength and as a proprietary dust containing 10 per cent active principle;[9] a proprietary dust mixture containing 2 per cent nicotine, 0.5 per cent rotenone, 25 per cent sulfur. The dosage rates of the above products for spray purposes and the toxicant strengths of self mixed dusts may be found in tables 1 and 2. The sprays were conditioned by the addition of a wetting agent[10] at the rate of half a pint in 100 gallons of water; the self mixed dusts contained talc as a carrier and included 5 per cent diatomaceous earth (by weight) as a fluffing agent.

The experimental area consisted of two adjacent blocks of Fordhook bush lima beans, each being 216 feet in length and having seven rows. The area was divided crosswise into eight sections or tiers, four alternate sections being allotted to spray tests and four to dusts and systemic sprays. The different treatments were represented by single row units that were arranged in a systematic series and occurred once in each section. Within the series were included two untreated rows. The position of the series in each section was altered with a view to obtaining a more equitable distribution of the different plots in the experimental area.

As part of experimental procedure it had been found advantageous to try and ensure an infestation of the two-spotted spider mite in the field by the introduction and distribution of mite infested lima bean plants, reared in greenhouse, along borders and between the two blocks of the experimental area shortly after plants had become established. Thus on June 20, 2 weeks after plant emergence above ground, 24 crocks containing infested plants were distributed and caged to prevent Mexican bean beetle injury. They were removed on July 1 after inspec-

[1] Diethyl p-nitrophenyl thiophosphate (parathion).
[2] Diethoxy thiophosphoric acid ester of 7-hydroxy-4-methyl coumarin (beta methyl umbelliferone). Compound E-838.
[3] Dialkyl nitroaryl thiophosphates.
[4] Referred to in this paper as EPN-300.
[5] Ethyl p-nitrophenyl thionobenzenephosphate.
[6] A commercial product of Geary Chemical Corp., New York.
[7] Octa-methyl pyrophosphoramide.
[8] Beta-chloroethyl-beta-(p. tertiary butyl phenoxy)-alpha-methyl ethyl sulfite.
[9] p-chlorophenyl, p-chlorobenzene sulfonate.
[10] *Triton B* 1956.

tion had indicated that an average of 93 and 96 per cent of young plants harbored mites. Despite this early indication of infestation by mites their activities did not seem to be of much significance until late July and early August, owing evidently to the retarding influence of cool humid weather conditions (Johnson 1950) on mite development, and owing to the abundance of foliage.

Applications of organophosphorus compounds for systemic purposes were made on July 1 and July 21, and of other spray materials on July 5, July 21 and August 11; dusts were applied in the very early morning on July 7, July 22 and August 11 in the presence of heavy dews. All applications were made by hand machines. Systemic sprays were applied at the average rate of 164 gallons per acre per application and other sprays at 185 gallons; dusts averaged 65 pounds per acre. Heavy rates were considered advisable for the two later applications in view of the dense growth of vines and foliage. Intervals between applications became lengthened and number of applications reduced from four to three as a result of unfavorable weather causing a delay in making the later applications, and in deference to the apparent lack of evidence of serious insect or mite infestation during the treatment period. However under drier conditions by day during August there was an increasing amount of feeding injury by mites up to the close of the experiment on August 30. In addition to the foregoing treatments it was felt necessary to spray the entire experimental area four times during the period July 8 to August 5 with bordeaux mixture (4.4.50) by means of power driven equipment as protection against downy mildew infection.

It was observed following the first application that sprays containing a chlorobenzene sulfonate compound had caused a notable amount of injury to plants as indicated by a puckering of the foliage, and this effect was not entirely eliminated when dosages of powder were reduced to 1.5 and 0.75 pounds per 100 gallons of water in the second and third applications. It was also noted that the

Table 1.—Prevalence of foliage injury by the Mexican bean beetle and two-spotted spider mite at close of experiment.

Spray Treatment; Amounts per 100 Gallons of Water	Scores Denoting Foliage Injury in Plots. Maximum 40	
	Mexican Bean Beetle	Two-Spotted Spider Mite
Parathion 25% wettable powder[1] 1 lb.	7	9
Parathion 25% wettable powder 8 oz.	6	11
A thiophosphate compound 30% emulsion[2] 1 pint	7	13
Ethyl paranitrophenyl thionobenzene phosphate wettable powder[3] 1 lb.	6	7
Ethyl paranitrophenyl thionobenzene phosphate wettable powder 8 oz.	7	8
Tetraethyl pyrophosphate 20% emulsion[4] 1 pint	10	12
Tetraethyl pyrophosphate 20% emulsion 8 fl. oz.	11	15
Alkyl-aryl thiophosphates 30% emulsion[5] 1 pint	10	13
Parathion 25% emulsion 1 pint	8	11
Methyl ethyl sulfite 15% wettable powder[6] 24 oz.	8	5
Chlorobenzene sulfonate 50% wettable powder[7] 2 lbs.	11	4
Chlorobenzene sulfonate 50% wettable powder 1 lb.	13	6
Checks	12½	23½
Octa-methyl pyrophosphoramide 63% solution[8] 2 pints	15	11
Octa-methyl pyrophosphoramide 63% solution 1 pint	10	11
Compound E-1059 32% solution[9] 3 pints	7	0
Compound E-1059 32% solution 2 pints	7	2
Checks	11½	23

[1] American Cyanamid Company.
[2] Product of Geary Chemical Corp., New York (E-838.)
[3] *EPN 300*, product of E. I. du Pont de Nemours.
[4] *Vapotone*, product of California Spray-Chemical Corp.
[5] Product of Geary Chemical Corp., New York.
[6] Product of Naugatuck Chemical, Naugatuck, Conn.
[7] Product of Dow Chemical Company, Midland, Mich.
[8] Product of Dow Chemical Company, Midland, Mich.
[9] Product of Geary Chemical Corp., New York.

dust containing 1.5 per cent methyl analog of parathion had caused the margins of occasional leaves to develop a "burnt" area. Such injury became more marked following the heavier applications on July 22 and August 11.

The results from treatment were expressed in terms denoting the condition of the foliage in the various plots at close of experiment in relation to the extent of injury sustained by feeding of the Mexican bean beetle and two-spotted spider mite respectively, and also according to the extent of discoloration on pods due to mite feeding. In scoring the foliage four classes were improvised to indicate the different extent of injuries sustained, and to each of which points were assigned; thus no injury received 0 points, trace 1 or 2, slight 3 or 4, moderate 5 to 7, severe 8 to 10, making a maximum score of 40 points for the four plots representing each treatment. These data are summarized in tables 1 and 2. In ascertaining the comparative yield per treatment the pods of fifty plants in each plot were picked, weighed and graded. The filled pods were further divided into lots having no mite injury or only a trace, slight, and moderate to severe, the first two grades being classed as marketable. These data are summarized in tables 3 and 4.

Due to the weakness of Mexican bean beetle infestation feeding injuries to foliage were limited in degree and extent, and differences between plots in these respects ranged within narrow limits. The data indicated that there was a minimum of foliage injury in plots sprayed or dusted with organophosphorus compounds applied for nonsystemic purposes, except in cases of tetraethyl pyrophosphate and dialkyl nitroaryl thiophosphates. The non-effectiveness of tetraethyl pyrophosphate treatment against Mexican bean beetle and spider mite in these tests was probably due in large measure to the extended intervals between applications and also in the case of dust by the occurrence of heavy dews on the foliage at time of application. Plots sprayed with an organophosphorus compound[1] for systemic purposes were notably free of foliage injury by Mexican bean beetle, comparing favorably in the circumstances with plots sprayed with parathion, *EPN 300*, or a new thiophosphate compound *E-838*. It should be noted that cryolite was added to methyl ethyl sulfite spray at the last application, a precaution in this case that served undoubtedly to reduce the extent of injuries in these plots by the Mexican bean beetle.

Table 2.—Prevalence of foliage injury by Mexican bean beetle and two-spotted spider mite at close of experiment.

Dust Treatment; Per Cent Strength of Active Ingredients	Scores Denoting Foliage Injury in Plots. Maximum 40	
	Mexican Bean Beetle	Two-Spotted Spider Mite
Parathion 1%	4	9
Parathion 0.5	4	15
Dimethyl parathion[1] 1.5%	5	16
EPN 300 1%	5	15
EPN 300 0.5%	5	19
Tetraethyl pyrophosphate 1%	11	21
Chlorobenzene sulfonate 10%	14	12
Nicotine 2%, rotenone 0.5%, sulfur 25%[2]	13	20
Checks	11½	23

[1] Alkyl-aryl thiophosphates. Product of Geary Chemical Corp., New York.
[2] Product of Tobacco By-Products and Chemical Corporation, Richmond, Virginia.

Feeding injuries to the foliage by two-spotted spider mite were more prevalent and more marked, and hence differences between plots in these respects ranged within wider limits. It was notable that plots sprayed with a systemic organophosphorus compound were nearly devoid of foliage injury by spider mites, more so than plots sprayed with systemic solutions of octa-methyl pyrophosphoramide. There was also a considerable reduction in mite injury in plots sprayed with suspensions of methyl ethyl sulfite and of chlorobenzene sulfonate, as well as with suspensions of ethyl p-nitro phenyl thionobenzene phosphate or parathion at the higher dosage strength. The latter phosphate treatments, employing wettable powders, were in the existing circumstances slightly more effective than treatments of parathion and other organic phosphate compounds prepared in water miscible or emulsion form.

A few of the chemical compounds applied as sprays were also applied as dusts, and of these only parathion and chlorobenzene sulfonate showed to some advantage in protecting the foliage from mite injury, the former being applied in a dust of 1 per cent toxicant strength and the latter at 10 per cent strength.

The extent of mite injury to pods was considerable as indicated by the amount of

Table 3.—Effectiveness of spray treatments for control of two-spotted spider mite as indicated by comparative yields of marketable and uninjured pods.

SPRAY TREATMENTS; AMOUNTS PER 100 GALLONS OF WATER	WEIGHT OF PODS IN POUNDS PER 100 PLANTS		GAIN, UNINJURED PODS OVER CHECKS
	Marketable	Uninjured	
Parathion 25% wettable powder 1 lb.	22.72	19.09	13.72
Parathion 25% wettable powder 8 oz.	17.40	12.56	7.19
E-838 thiophosphate 30% emulsion 1 pint	17.00	10.44	5.07
EPN 300 30% wettable powder 1 lb.	25.38	22.69	17.32
EPN 300 30% wettable powder 8 oz.	26.94	22.50	17.13
Tetraethyl pyrophosphate 20% emulsion 1 pint	19.47	13.97	8.60
Tetraethyl pyrophosphate 20% emulsion 8 fl. oz.	17.56	11.94	6.57
Alkyl-aryl thiophosphates 30% emulsion 1 pint	22.97	19.78	14.41
Parathion 25% emulsion 1 pint	24.59	19.50	14.13
Methyl ethyl sulfite 15% wettable powder 24 oz.	24.59	22.59	17.22
Chlorobenzene sulfonate 50% wettable powder 2 lbs.	18.87	15.12	9.75
Chlorobenzene sulfonate 50% wettable powder 1 lb.	17.90	13.50	8.13
Checks	10.98	5.37	
Octa-methyl pyrophosphamide 63% solution 2 pints	22.52	17.97	10.10
Octa-methyl pyrophosphoramide 63% solution 1 pint	24.79	22.62	14.75
Compound E-1059 32% solution 3 pints	28.84	26.72	18.85
Compound E-1059 32% solution 2 pints	27.52	25.36	17.49
Checks	13.82	7.87	

discoloration in untreated or less effectively treated plots. There was a wide range of differences in this respect between treatments. The data served in several instances to support that obtained in foliage protection, though not always so. Plots sprayed with the organophosphorus compounds *E-1059* and *EPN 300*, and with a powder suspension of methyl ethyl sulfite gave the greatest increases of clean uninjured pods over checks, thus repeating the successful results attained in foliage protection against spider mites. On the other hand yields from plots sprayed with suspensions of chlorobenzene sulfonate powder were depressed following chemical injury to foliage, and failed to verify the more promising indications presented by the data on foliage protection against mite injury. There were also notable increases in yield of uninjured pods in plots sprayed with emulsions containing parathion or dialkyl nitroaryl thiophosphates, suspensions of parathion powder at the higher dosage, and with a spray solution of octa-methyl pyrophosphoramide at the lower dosage strength, results which with the exception of parathion were considered more promising than was indicated by the extent of foliage protection against mites as a result of treatment. It will be noted that plots sprayed with the thiophosphate compound *E-838* and with tetraethyl pyrophosphate did not average as large gains as plots sprayed with the foregoing compounds, and that in these plots the foliage was not as

Table 4.—Effectiveness of dust treatments for control of two-spotted spider miite as indicated by comparative yields of marketable and uninjured pods.

DUST TREATMENT; PER CENT STRENGTH OF ACTIVE INGREDIENTS	WEIGHT; POUNDS PER 100 PLANTS		GAIN OR LOSS OF UNINJURED PODS OVER CHECKS
	Marketable	Uninjured	
Parathion 1%	22.98	20.68	12.81
Parathion 0.5%	21.47	19.84	11.97
Dimethyl parathion 1.5%	20.58	15.51	7.64
EPN 300 1%	24.15	17.72	9.85
EPN 300 0.5%	16.29	5.33	−2.54
Tetraethyl pyrophosphate 1%	15.14	7.79	−0.08
Chlorobenzene sulfonate 10%	21.12	19.73	11.86
Nicotine 2%, rotenone 0.5%, sulfur 25%	19.45	14.67	6.80
Checks	13.82	7.87	

effectively protected against spider mite injury.

In the case of dusts there were notable gains in yield of uninjured pods from plots treated with parathion and a 10 per cent chlorobenzene sulfonate mixture. In the latter case there was comparatively little evidence of chemical injury to foliage such as had occurred in plots sprayed with this compound. *EPN 300* dusts were not as effective as *EPN 300* sprays. The average yield of uninjured pods from plots dusted with a 1 per cent *EPN 300* mixture was slightly less than that from plots dusted with a 1 per cent parathion mixture, and slightly more than from plots dusted with 1.5 per cent dimethyl analog of parathion.

SUMMARY.—The following sprays and dusts were tested under field conditions for control of Mexican bean beetle and two-spotted spider mite on lima beans. Sprays (amounts per 100 gallons of water), parathion 25 per cent wettable powder and *EPN 300*, 30 per cent wettable powder, at 1 pound and 0.5 pound, methyl ethyl sulfite 15 per cent wettable powder 1.5 pounds, parathion 25 per cent emulsion, dialkyl nitroaryl thiophosphates 30 per cent emulsion, Compound *E-838* thiophosphate 30 per cent emulsion, each at 1 pint, tetraethyl pyrophosphate 20 per cent solution 1 pint and 0.5 pint, and the systemic insecticides octa-methyl pyrophosphoramide 63 per cent solution 2 pints and 1 pint, Compound *E-1059* 32 per cent solution 3 pints and 2 pints; Dusts (percentage toxicant), parathion and *EPN 300* at 1 and 0.5 per cent, dimethyl analog of parathion 1.5 per cent, tetraethyl pyrophosphate 1 per cent, chlorobenzene sulfonate 10 per cent, a mixture of nicotine 2 per cent, rotenone 0.5 per cent and sulfur 25 per cent. The systemic insecticide treatments were applied twice at average rate of 164 gallons per acre per application, other treatments three times at an average of 185 gallons for sprays and 65 pounds per acre for dusts, rates being heavy owing to dense growth of vines and foliage. Bordeaux mixture (4-4-50) was applied four times in order to prevent mildew infection.

Spray suspensions containing chlorobenzene sulfonate were injurious to plant growth, whereas a dust containing 10 per cent toxicant was comparatively unharmful: a dust having 1.5 per cent methyl analog of parathion caused foliage injury.

Spray treatments containing the new organophosphorus compounds *EPN 300*, Compound *E-838*, the systemic *E-1059*, in addition to parathion, reduced feeding by the Mexican bean beetle to a minimum, whereas there was little indication of foliage protection with treatments containing a chlorobenzene sulfonate powder or the systemic octa-methyl pyrophosphoramide, as applied. The most effective spray treatments for mite control as indicated by the extent of foliage protection and yield of uninjured pods were those containing the systemic compound *E-1059*, suspensions of *EPN 300* and of, methyl ethyl sulfite. There were also large increases of uninjured pods in plots treated with a suspension of parathion at the higher dosage strength, with parathion and dialkyl nitroaryl thiophosphates as emulsions, and with the systemic octa-methyl pyrophosphoramide, also from plots dusted with parathion and with chlorophenyl chlorobenzene sulfonate.

A dust of 1 per cent *EPN 300* strength was not as effective for mite control as a spray containing 1 pound of 30 per cent *EPN 300* wettable powder in 100 gallons of water, and a dust containing 1.5 per cent dimethyl analog of parathion was not as effective as a 1 per cent parathion mixture. The thiophosphate compound *E-838* whilst promising for Mexican bean beetle control was less satisfactory against the two-spotted spider mite at the strength applied. The noneffectiveness of tetraethyl pyrophosphate treatment was probably due in part to the extended intervals between applications and thus the restricted number of applications made, and also more particularly in the case of dust treatment due to heavy dews on the foliage at time of applications.

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The Relative Efficiency of Some Insecticides for Japanese Beetle Control

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Within recent years DDT has been generally used for the control of Japanese beetles. Prior to its advent there was not an economical insecticide available that could be termed efficient for controlling this insect. Following the introduction of DDT there has been developed a number of insecticides that are highly efficient for the control of the Japanese beetle. Their use in Maryland has not become generally accepted. There are probably several reasons for this:

1. The effectiveness of DDT is well established in the minds of people.
2. The knockdown rate of several of the newer insecticides is quite slow and most people desire to see beetles fall rapidly following spraying.
3. There is much confusion as to the proper dosages for using some of these insecticides.

Several papers have been published covering the effectiveness of DDT. Fleming & Chisholm (1944) published on it as a protective spray. Langford & Cory (1945) published on its usefulness for controlling Japanese beetles on fruit. Fleming & Maines (1950) published on the effectiveness of methoxychlor and TDE, and Langford & Squires (1947) published on benzene hexachloride and chlordane. Several other insecticides are now available which show distinct promise for controlling the Japanese beetle. Most of the available information covering their use is from unpublished data and casual observations. Most notable among these are lindane, parathion, toxaphene, aldrin and dieldrin.

At the outset it should be stated that it is not the purpose of this paper to establish dosages of the various insecticides for use in the control of the Japanese beetle. Even with the generally accepted insecticide DDT, the dosage required for different conditions is quite variable. Normally 1 pound of DDT in 100 gallons of water is recommended for general spray work. This dosage is quite effective for killing all beetles contacted by the spray, but it is not effective under conditions of heavy infestation for providing long periods of protection on favored host plants. It may be expected that favored food plants sprayed with the 1 pound dosage will be freed of beetles and protected for a period of from 5 days to 2 weeks, depending on the intensity of the beetle population. Under similar conditions the period of protection may be lengthened appreciably by increasing the amount of DDT used. This paper is presented to give information on the results obtained with other promising insecticides, using DDT as the standard. The following insecticides were studied: Aldrin, DDT, chlordane, dieldrin, benzene hexachloride, lindane, methoxychlor, TDE, toxaphene and parathion.

The insecticides are evaluated on the basis of total kills obtained within given periods from both spraying and residual action. With most of the insecticides, tests were made with both emulsions and wettable powders. Aside from general field tests which showed all of the insecticides to be effective for killing Japanese beetles and providing protection for foliage, detailed tests were made under laboratory conditions in an effort to determine the relative amounts of the different insecticides required to produce equivalent results. Laboratory spraying was done with a hand sprayer and the insecticides were applied directly to the beetles in amounts and under conditions which were similar. The effect of the residue action was studied by placing beetles on blotters which were dipped in the insecticide and allowed to dry thoroughly before using. The insects were held on the blotters for a twenty-four hour testing period. The laboratory data presented consists of summary averages of a series of tests. A test involved the treatment of from 10 to 20 insects and each test was replicated from 5 to 20 times. Field work involved spraying of Japanese beetle infested foliage as encountered under field conditions.

After exposure to the insecticides, either by spraying or placing on blotters, observations were made at intervals of 15 minutes, 30 minutes, 1 hour, 2 hours,

4 hours and 24 hours to determine the rapidity of knockdown and kill. In these studies the term knockdown represents the beetles which were on their backs and incapable of righting themselves. The term kill denotes beetles which were completely dead at the moment of observation. Because of these definitions the ultimate efficiency of some of the insecticides, studied, may vary from the data presented in this paper. The reason for this is because at the period when final observations were made, many of the beetles showed signs of life through feeble leg or other movements. Often knockdown was complete and it was obvious that ultimately death would ensue, but because of definition and method it was necessary to record the insect as living.

THE KNOCKDOWN OR PARALYZING EFFECTS.—The rapidity of knockdown or paralyzing effect from the different insecticides varied widely. Two major types of knockdown were observed. The first type was very rapid and often within a period of 1 hour or less, a majority of the insects would be on their backs and incapable of righting themselves. The second type of knockdown was gradual and it built up from a low initial knockdown to almost a 100 per cent over a 24-hour period. The insecticide giving the most rapid knockdown was the gamma isomer contained in benzene hexachloride and lindane. The other insecticides which give very rapid or quick knockdowns were: methoxychlor, DDT, TDE and parathion. The knockdown from chlor-

Table 1.—Results showing knockdown and kill of Japanese beetles by spraying, using 1 pound of insecticide to 100 gallons of water, unless otherwise noted.

	Period of Exposure									
	30 Min.		1 Hr.		2 Hrs.		4 Hrs.		24 Hrs.	
Insecticide	Down	Dead	Down	Dead	Down	Dead	Down	Dead	Down	Dead
Methoxychlor										
Emulsion	100	0	100	40	100	56	100	62	100	100
W. P.	82	0	100	4	100	6	100	20	100	92
Parathion										
Emulsion—0.25 lb.	71	13	98	58	100	63	100	79	100	98
W. P.—0.166 lb.	30	0	84	18	100	66	100	74	100	100
Lindane										
Emulsion—0.1 lb.	100	2	100	38	100	38	100	72	100	—
W. P.	—	—	—	—	—	—	—	—	—	—
DDT										
Emulsion	99	15	100	19	100	21	100	30	100	99.5
W. P.	78	0	91	4	98	11	98	14	100	96
TDE										
Emulsion	92.7	3	97.3	—	100	6	100	17	100	99.3
W. P.	00	0	02	0	96	0	100	6	100	96
Aldrin										
Emulsion	14	0	54	0	62	38	—	—	100	100
W. P.	—	—	—	—	—	—	—	—	—	—
Dieldrin										
Emulsion	10	0	40	0	90	0	—	—	100	94
W. P.	—	—	—	—	—	—	—	—	—	—
Chlordane										
Emulsion—0.75 lb.	4	0	6	0	14	0	22	0	100	100
W. P.—0.60 lb.	—	—	2	0	6	0	—	14	100	98
Toxaphene										
Emulsion	20	0	34	0	—	—	50	0	—	—
W. P.	6	0	8	0	26	0	—	—	100	—

Insecticide dosage in all cases represents pounds of actual chemical in 100 gallons of water. Data expressed as percentage of beetles down or dead. Dead indicates complete death. Down indicates percentage of beetles down or dead.

Table 2.—Results obtained by spraying in studying the comparative effectiveness of insecticides for killing the Japanese beetle.

	Dosage—Pounds per 100 Gallons of Water									
	0.1 lb.		0.27 lb.		0.5 lb.		0.75 lb.		1 lb.	
Insecticide	Down	Dead	Down	Dead	Down	Dead	Down	Dead	Down	Dead
DDT										
Emulsion	100	78	100	82	100	96	—	—	100	99.1
W. P.	98	40	100	80	100	96	—	—	100	96.1
Methoxychlor										
Emulsion	100	92	100	86	100	82	100	99	100	100
W. P.	98	50	98	40	98	74	—	—	100	92
Chlordane										
Emulsion	—	—	100	94	100	98	100	100	100	—
W. P.	—	—	86	—	100	100	100	98	—	—
TDE										
Emulsion	—	—	—	—	98	64	100	93	100	99.3
W. P.	80	—	—	—	—	—	100	—	100	100
Toxaphene										
Emulsion	—	—	100	84	100	100	—	—	—	—
W. P.	58	18	—	—	—	—	—	—	100	100
Dieldrin										
Emulsion	—	—	—	—	—	—	—	—	100	94
W. P.	—	—	—	—	—	—	—	—	—	—
Aldrin										
Emulsion	100	100	100	100	100	100	—	—	—	—
W. P.	—	—	—	—	—	—	—	—	—	—
	0.1 lb.		0.05 lb.		0.033 lb.		0.0028 lb.		0.0014 lb.	
Parathion										
Emulsion	100	100	100	100	100	100[1]	—	—	—	—
W. P.	100	98	—	—	100	100	100	100	100	100
Lindane (Gamma Isomer)										
Emulsion	100	100	100	100	100	100[1]	—	—	—	—
W. P.	—	—	—	—	—	—	100	100	100	100

[1] Not tested at lower doses. Insecticide dosage in all cases represents pounds of actual chemical in 100 gallons of water. Data expressed as percentage of beetles down or dead in 24 hrs. Down indicates percentage of beetles down or dead.

dane, dieldrin, aldrin and toxaphene when compared pound for pound with DDT was slow and gradual, but ultimate kills were good. The slowest knockdown came from chlordane, table 1 gives results which show the rate or rapidity of knockdown for the different insecticides when sprayed on the insects at dilutions, unless otherwise noted, of 1 pound of actual insecticide in 100 gallons of water. The table also shows the relation between knockdown and complete kill immediately following spraying and over a period of 24 hours. It will be noted that where emulsions and wettable powders are compared on a pound basis, the emulsions in most instances gave a faster initial knockdown than the wettable powders.

KILLING EFFICIENCIES.—The total effectiveness of the insecticides, involved in these tests for paralyzing or knocking beetles down does not necessarily represent the total efficiency of the insecticides for killing the insects. It is possible to use small dosages of a number of these insecticides and obtain a good knockdown, but a rather inefficient kill. This result has been frequently encountered in the field, particularly with DDT in airplane spraying to control Japanese beetles in corn. On numerous occasions results have been observed where almost complete knockdown was obtained immedi-

ately following spraying, but after a few hours the beetles got up and either resumed feeding or flew away. Similar results have been experienced in the field with DDT dusts. In the laboratory Japanese beetles sprayed with an emulsion of DDT containing 0.05 pound per 100 gallons of water produced a 100 per cent knockdown over a 24-hour period, but total kill was only 48 per cent. Often with low dosages of the insecticides the total knockdown at the end of a 24-hour period was quite high, but total kill was relatively low. These differences between knockdown and kill were not obvious in the tests made with parathion and lindane. Rather infinitesimal amounts of these insecticides produced outstanding knockdowns and kills. It is possible that the dosages used, in the case of these materials, did not reach the sub-lethal point required to make the differences obvious.

Field observations indicated that all of the insecticides involved in this study would give good control of the Japanese beetle if used at the proper dosage level. Satisfactory control in the field was obtained with DDT, methoxychlor, TDE, chlordane, toxaphene, dieldrin, and aldrin at a dosage level of 1 pound of technical material in 100 gallons of water. Effective control was obtained with both wettable powders and emulsions in the case of all the insecticides with the exception of aldrin and dieldrin. These latter two materials

Table 3.—Results obtained through residual action in studying the comparative effectiveness of insecticides for killing the Japanese beetle.

	0.1 Lb.		0.25 Lb.		0.5 Lb.		0.75 Lb.		1 Lb.	
Insecticide	Down	Dead	Down	Dead	Down	Dead	Down	Dead	Down	Dead
DDT										
Emulsion	100	50	—	—	100	62	—	—	100	80
W. P.	—	—	100	66	100	82	—	—	100	98
Methoxychlor										
Emulsion	100	100	—	—	—	—	—	—	—	—
W. P.	94	66	100	76	100	100	—	—	100	82
Chlordane										
Emulsion	—	—	88	46	100	100	—	—	—	—
W. P.	98	70	—	—	100	100	—	—	—	—
TDE										
Emulsion	—	—	—	—	96	30	100	100	100	98
W. P.	8	8	—	—	100	74	100	100	100	100
Toxaphene										
Emulsion	—	—	—	—	100	94	—	—	—	—
W. P.	—	—	98	56	100	82	—	—	100	98
Dieldrin										
Emulsion	—	—	—	—	—	—	—	—	100	88
W. P.	—	—	—	—	—	—	—	—	—	—
Aldrin										
Emulsion	—	—	100	98	100	100	—	—	—	—
W. P.	—	—	—	—	—	—	—	—	—	—
	0.1 lb.		0.05 lb.		0.03 lb.		0.0033 lb.		0.0014 lb.	
Parathion										
Emulsion	100	100	100	96	—	—	—	—	—	—
W. P.	100	100	—	—	100	98	72	40	—	—
Lindane										
Emulsion	100	100	—	—	—	—	—	—	—	—
W. P.	—	—	—	—	100	100	—	—	100	78
γ Benzene hexachloride	—	—	—	—	100	—	—	—	—	—

Insecticide dosage in all cases represents pounds of actual chemical in 100 gallons of water. Data expressed as the percentage of beetles down or dead at the end of a 24-hour period. Dead indicates complete death.

were found effective as emulsions, but they were not tested as wettable powders.

Tables 1, 2 and 3 show that methoxychlor, TDE, chlordane, toxaphene, aldrin and dieldrin, under laboratory conditions all compare rather favorably with DDT and each other, both as sprays and residues, when used pound for pound. Aldrin was outstanding in its performance. Dieldrin was somewhat less effective than aldrin. The emulsions generally gave a faster rate of knockdown and kill than the wettable powders.

Under field conditions both lindane and benzene hexachloride gave excellent kill and foliage protection when used in spray solutions containing 0.1 pound of gamma isomer to 100 gallons of water. Spray solutions with this gamma isomer content gave a much faster beetle knockdown and kill than sprays containing 1 pound of DDT to 100 gallons. Likewise, 0.3 of a pound of parathion in 100 gallons of water, either in emulsion or as wettable powder gave outstanding kills under field conditions. This dosage of parathion, however, did not appear to give the long-standing residual protection given by the other materials. In laboratory studies, Tables 1, 2 and 3 show that lindane and parathion produced outstanding kills at relatively small dosages. Spray solutions containing .0014 lb. of the gamma isomer of lindane gave a 100 per cent knockdown and kill during a period of 24 hours. The same dose of technical parathion gave a 98 per cent kill.

SUMMARY.—Both field and laboratory tests indicated that DDT, benzene hexachloride, lindane, parathion, aldrin, chlordane, methoxychlor, TDE, dieldrin and toxaphene were effective, either as emulsions or wettable powders, for killing Japanese beetles and protecting plants.

Laboratory studies, based on spraying and the exposure of beetles to residues, indicated that aldrin, chlordane, methoxychlor, TDE, dieldrin and toxaphene all compared favorably with DDT for killing beetles when used pound for pound. In laboratory tests spray solutions containing .0014 lb. of either technical parathion or lindane gave complete knockdown and kills of 98 and 100 per cent over a period of 24 hours. In field tests where either 0.3 lb. of technical parathion and 0.1 lb. of gamma isomer in 100 gallons of water was used as a spray, satisfactory kills were obtained and plants were freed of beetles.

The initial knockdown from DDT, methoxychlor, lindane, parathion and TDE was much faster than that from aldrin, chlordane, dieldrin and toxaphene.

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DR. THOMAS C. WATKINS ON LEAVE

Dr. Thomas C. Watkins, Professor of Economic Entomology at Cornell University, has recently arrived at the University of Miami, Coral Gables, Florida, where he will complete a sabbatical leave study. He will devote his major attention to studies and collections of insect pests of sub-tropical plants, including citrus. He is making his headquarters at the new Sub-tropical Horticultural Farm recently established at the University of Miami, under the direction of Prof. S. J. Lynch.

Enroute to Miami, Dr. Watkins spent considerable time on similar activities with various laboratories on insect pests of cotton, vegetables, and forest plantations.

Seed Treatments for Control of the Seed-Corn Maggot in Northern California

W. H. Lange, Jr., E. C. Carlson, and W. R. Corrin[1]

The seed-corn maggot, *Hylemya cilicrura* (Rond.), causes extensive damage in California to germinating bean, corn, pea, or other seeds, by boring into the cotyledons or the plumule. In addition to this typical injury the maggot burrows into the stems of seedling beans, onions, and other plants, often causing deformities in growth, or death of the plants. It has also been reared from the leaf petioles of spinach and celery. The present investigations deal with its control on germinating lima beans in the Santa Clara Valley of California.

Damage to lima beans is usually more severe during wet, cold periods than under optimum germinating conditions. In the Santa Clara Valley severe damage is often associated with double-cropping practices—using lettuce or spinach as a spring crop, followed by beans. The non-harvested portion of the crop is disked into the soil, the field is furrow irrigated, and lima beans are planted as soon as the field is dry enough to permit the entrance of heavy equipment. Conditions for flies are also enhanced by the liberal application of organic matter in the form of rotting bean refuse and manures.

In the past no adequate control has been known. Damage was lessened, however, by the use of certain cultural practices. These included the proper timing of planting in relation to soil moisture and soil temperature; planting additional seed; or the use of single-cropping practices.

During 1949 approximately 20,000 pounds of Fordhook lima beans were treated with lindane and a fungicide for a combination wireworm-seed decay control in this area. Good wireworm control was obtained, no pronounced injury was apparent, and a certain amount of seed-corn maggot damage was alleviated. In the Santa Clara Valley during 1950, 245,700 pounds of Fordhook beans and 21,635 pounds of baby lima beans were treated with a dry or slurry mixture containing the equivalent of 0.33 ounce of 75 per cent lindane per 100 pounds of beans together with an appropriate fungicide. Good control of wireworms and seed-corn maggots was obtained.

In connection with lindane and other seed treatment investigations for wireworm control, Lange *et al.* (1949) observed that a certain degree of seed-corn maggot control was obtained. The same authors (1950) also reported preliminary tests involving the treatment of lima bean seed with chlordane.

The older, and even some of the more recent, literature dealing with seed-corn maggot control by means of seed treatments is not encouraging. Turner (1945) used a 3 per cent DDT dust as high as 1 per cent by weight and found no marked reduction of seed-corn maggot infestation. Ristich and Schwardt (1949) state that seed treatments give little promise as a method for seed-corn maggot control.

Dills & Odlund (1949) in testing 25 different mixtures as seed treatments on corn and lima beans reported best control of seed-corn maggot with 50 per cent methoxychlor.

Methods of Treating.—The methods of treating seed are described in the article by Lange *et al.* (1949). Insecticides and fungicides were applied in 1949 to 100-pound lots of seeds in a commercial slurry treater. The machine was calibrated to determine the average pocket weight, and the cups were fed individually by hand.

In 1950 the liquid fixation method was used. Five pound lots of seed were treated in a revolving cement mixer. The dry chemicals were mixed with the seed, and as the seed mixed 0.5 per cent by weight of water was sprayed into the seed, in which was usually incorporated 0.1 per cent by total seed weight of a methyl cellulose solution.[2] The use of this amount of moisture did not necessitate a special drying operation. The use of the sticker

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[2] A 10 per cent water solution of hydroxyethyl cellulose, supplied by Carbide and Carbon Chemical Corporation, used at the rate of 45.4 grams per 100 pounds of seed.

insured a more even dispersion of the chemicals and less loss of chemicals during subsequent handling of the seed.

TOLERANCE OF LIMA BEANS.—Experiments conducted during 1949 presented in the paper by Lange *et al.* (1949) indicated that Fordhook lima beans are very sensitive to certain chemical seed treatments; in fact they are more sensitive than Ventura limas and baby limas. Lindane at 0.66 and 1.33 ounces per 100 pounds of beans either caused an effect on growth or interfered with the absorption of the cotyledons. Aldrin and dieldrin also had some effect on rate of emergence and upon seedling weight, when used at the rate of 2 ounces of 25 per cent wettable powder per 100 pounds of beans. Chlordane appeared safer as a seed treatment.

Field observations during 1949 suggested that differences in the tolerance of large lima beans to chemical seed treatments appeared related to the vigor of individual seed lots. To check this further, Fordhook Concentrated Bush Lima beans of low and high germination were treated with certain chemicals and planted in pasteurized soil in the greenhouse at Davis. The chemicals were applied as suspensions in water using 0.5 per cent moisture, in a small laboratory treater. The effects upon the seed were determined as the per cent total emergence, as mean emergence period by means of the method used by Leach & Smith (1945), and as average seedling weight.

The results of these tests summarized in table 1 indicate that chlordane, aldrin, and dieldrin at the rates specified had no apparent effect upon total per cent emergence, mean emergence period, or seedling weight of a high per cent germinating seed (87 per cent), but did cause a slight delay in emergence of a low per cent germinating seed (72 per cent).

Table 1.—Effect of several chemicals as wet applications on Fordhook Concentrated Bush Lima beans grown in pasteurized soil at Davis.

TREATMENT	DOSAGE AS PER CENT OF WEIGHT OF SEED	PER CENT EMERGENCE	MEAN EMERGENCE PERIOD IN DAYS	AVERAGE SEEDLING WEIGHT IN GRAMS
June 10, 1949—high germination seed (87%)				
Not treated	none	87.5	9.73	8.36
Chlordane, 40%	0.250	83.3	9.18	8.64
Aldrin, 25%	0.125	89.2	8.56	8.00
Aldrin, 25%	0.250	91.7	8.69	7.74
Dieldrin, 25%	0.125	89.2	9.18	8.10
Dieldrin, 25%	0.250	93.3	9.74	8.08
Least significant difference:				
5% level			n.s.	n.s.
1% level			n.s.	n.s.
June 24, 1949—low germination seed (72%)				
Not treated	none	72.5	9.14	10.37
Chlordane, 40%	0.125	76.7	8.83	10.02
Aldrin, 25%	0.125	75.0	10.00	8.91
Dieldrin, 25%	0.125	76.7	9.38	9.81
Least significant difference:				
5% level			0.74	n.s.
1% level			1.07	n.s.

The tolerance of Fordhook Concentrated Bush Lima beans to the chemicals used in the 1950 experiments can be seen by reference to tables 4 and 5 and the discussion of the results of these experiments.

RESULTS IN 1949.—A single lot of 1947 Fordhook Concentrated Bush Lima beans of 72 per cent germination was divided into 100-pound lots and treated in a commercial slurry treater with the

Table 2.—Effect of a slurry treatment using 2 ounces of several chemicals per 100 pounds of Fordhook Concentrated Bush Lima bean seed on emergence, seed decay, and seed-corn maggot injury.[1]

TREATMENT[3]	EMERGENCE PER 100 FEET ROW		PER CENT PLANTS NOT EMERGED[2]	PER CENT SEED DECAY[2]	PER CENT MAGGOT INJURY[2]	
	June 7	June 9			Non-Emerged and Emerged	Emerged Cotyledons
Chlordane, 40%	87.2	98.4	30.5	19.4	19.4	2.2
Dieldrin, 25%	57.2	67.2	53.9	30.3	34.2	15.5
Aldrin, 25%	70.4	71.6	41.1	30.1	24.7	7.8
Check	80.8	104.8	28.6	11.6	50.0	68.8
Least significant difference:						
5% level	13.7	14.0			14.1	8.8
1% level	18.4	18.8			18.8	12.2

[1] Seed treated May 27, 1949, planted May 28, 1949. [2] Dug 12 replications of 5 feet of row on June 14, 1949.
[3] All seed previously treated with a fungicide (4 ounces tetrachloro-para-benzoquinone, per 100 pounds seed).

Table 3.—Effect of chemical seed treatments on final emergence of Fordhook Concentrated Bush Lima beans and on seed-corn maggot damage. Bowers field, Santa Clara.

Treatment per 100 Pounds Seed[1]	Average Plants per 100 Feet Row		Per Cent Seed Decay[3]	Average Per Cent Maggot Damage to Cotyledons and Plumules[3]
	Normal Plants	Total Plants[2]		
A—Fungicide alone[4]	185	401	1.2	74.01
B—Lindane 0.33 oz. 75%[4]	591	646	2.3	4.33
C—Chlordane 2.00 oz. 40%[4]	437	458	2.4	1.97

[1] Seed treatment (B and C) May 16, 1950, in commercial slurry treater. Planted June 9, 1950.
[2] Total of all plants emerged on July 11, 1950.
[3] Determined by digging two 10 feet lengths of row for each treatment on June 20, 1950.
[4] Treated with tetrachloro-para-benzoquinone, 4 ounces per 100 pounds of seed as a dry powder.

following insecticides: chlordane, 40 per cent; dieldrin, 25 per cent; aldrin, 25 per cent; and untreated check. The dosage used was 2 ounces of chemical by weight per 100 pounds of beans. The seed had been previously treated with tetrachloro-para-benzoquinone as a dry treatment at the rate of 4 ounces per 100 pounds of seed. No additional fungicide was added. Seed from these treatments was planted in single replicated rows on four different ranches in the Santa Clara Valley during May, 1949.

The results of these tests indicated several trends as follows: (1) a delay in germination with aldrin and dieldrin, but less delay, or in one case "stimulation," with chlordane; (2) a reduced total emergence for all treatments in comparison with untreated seed; (3) a possible increase in seed decay of treated seed in comparison with fungicide treatment above; and (4) a fair control of seed-corn maggot, if expressed as a reduction of cotyledon and plumule injury of emerged beans.

In one instance, 12 replications of 5 feet of row were dug up 16 days after planting. The results in table 2 indicate a high degree of non-emergence for this particular planting. The control of maggots in this case with the chlordane treatments may be due to the rapid emergence which on June 7 was even higher than with the untreated beans.

In several commercial lima bean fields during 1949 the seed was treated with lindane at the rate of 0.66 ounce of 25 per cent formulation per 100 pounds of seed together with a fungicide.[3] A

[3] 95 per cent tetrachloro-para-benzoquinone; 1.5 ounces per 100 pounds seed.

Table 4.—Effect of chemical seed treatments of Fordhook Concentrated Bush Lima beans on emergence, and incidence of seed-corn maggot damage. Alleman field, Gilroy, 1950.

Treatment per 100 Pounds Seed[1]	Plants per 100 Seeds Planted,[2] Average		Maggot Damage,[3] Per Cent		Per Cent Reduction in Total Maggot Injury[4]
	Total	Normal	Cotyledons	Cotyledons and Roots	
Lindane 1.00 oz. 75%	73.2	70.2	2.1	3.3	87.7
Lindane 0.66 oz. 75%	69.8	67.2	3.9	5.6	80.0
Lindane 0.33 oz. 75%	77.0	73.7	3.6	4.4	83.1
Chlordane 1.00 oz. 40%	71.0	68.0	9.2	15.1	41.5
Chlordane 2.00 oz. 40%	70.2	68.5	11.3	12.1	53.9
Aldrin 1.00 oz. 25%	69.7	68.0	8.4	10.9	60.0
Dieldrin 1.00 oz. 25%	73.8	71.5	0.8	1.2	95.4
No insecticide, check	75.2	68.2	17.8	23.1	—
Least significant difference:					
5% level	n.s.	n.s.		7.6	
1% level	n.s.	n.s.		10.1	

[1] Seed all previously dry treated with a fungicide, tetrachloro-para-benzoquinone, 4 oz. per 100 pounds seed. All treatments except check treated by liquid fixation on May 22, 1950, using methyl cellulose solution.
[2] Planted May 24, 1950; final counts made June 15, 1950.
[3] Determined by digging all seedlings in 6 replications of 10 feet of row.
[4] Based upon reduction in number of root and cotyledon damaged seedlings of treatments in comparison with check.

check of three fields gave an average of 3 per cent maggot injury for seed treated with fungicide alone, and less than 1 per cent for the lindane-fungicide combination. This low average infestation and the spotty nature of the infestations made it difficult to evaluate the benefit derived from seed treatments.

EXPERIMENTS IN 1950.—Several experiments dealing with seed treatments were conducted during 1950. The first to be discussed was aimed at simulating grower practices relative to seed treatment. A seed lot previously treated with a fungicide (Spergon) as a dry powder was again treated in a commercial slurry treater with either lindane or chlordane at the stated concentrations. Four rows through two entire fields were planted with a Ventura planter, using untreated rows on either side. One field had no infestation. The data summarized in table 3 indicates a marked reduction in the severity of seed-corn maggot damage to the cotyledons and plumules using lindane at the rate of 0.33 ounce of 75 per cent formulation, and chlordane at 2 ounces of 40 per cent wettable powder per 100 pounds of seed, together with a fungicide. The treatments also greatly increased the number of normal plants, had no significant effect on seed decay, and did not cause delay in emergence.

In a second series of experiments the liquid fixation method was tested. Seed was treated with fungicides and insecticides as dry powders in a cement mixer and 0.5 per cent moisture containing a methyl cellulose sticker sprayed on as the seed revolved. Lindane, chlordane, aldrin, and dieldrin were tested at the concentrations stated. Six replications were used of each treatment in plots two rows wide by 25 feet long. One row of each plot was dug and the other left for emergence counts. The data summarized in table 4 indicates a light infestation of maggots in this case. There was no significant difference between the number of total or normal plants in the treatments as compared with the untreated seed. The best reduction in severity of cotyledon

Table 5.—Results obtained from chemical seed treatments of Fordhook Concentrated Bush Lima beans in relation to emergence, seed decay, and seed-corn maggot injury. Bowers field, Santa Clara, 1950.

TREATMENT PER 100 POUNDS SEED[1]	AVERAGE PER CENT EMERGENCE[2]		PER CENT SEED GERMINATION[3]	PER CENT SEED AND SEEDLING DECAY	PER CENT MAGGOT INJURY		PER CENT REDUCTION IN TOTAL MAGGOT INJURY[4]
	Total	Normal			Cotyledons	Cotyledons and Roots	
Lindane 0.33 oz. 75%	68.8	58.8	89.6	8.6	8.1	17.2	72.9
No fungicide							
Lindane 0.33 oz. 75%	66.2	56.3	91.5	7.5	15.1	31.6	52.1
Fungicide 2 oz.[5]							
Lindane 0.33 oz. 75%	67.8	58.8	82.0	11.8	8.5	12.3	81.4
Fungicide 4 oz.[5]							
Lindane 0.33 oz. 75%	67.8	66.5	87.6	6.0	2.8	10.6	90.7
Fungicide 1.33 oz.[6]							
Chlordane 2 oz. 40%	70.3	53.3	86.7	6.9	7.8	10.6	90.7
Fungicide 2 oz.[5]							
Aldrin 2 oz. 25%	59.7	57.8	89.3	12.9	1.3	2.2	96.4
Fungicide 2 oz.[5]							
Dieldrin 1 oz. 25%	65.5	58.0	93.7	12.7	0.9	4.1	93.6
Fungicide 2 oz.[5]							
Fungicide 2 oz.[5]	59.7	43.2	90.0	5.7	20.1	38.3	37.1
Fungicide 1.33 oz.[6]	72.5	60.3	96.0	4.4	21.3	29.3	47.9
No treatment	56.0	31.7	81.9	4.4	46.3	61.7	—
Least significant difference:							
1% level		8.2		6.4	12.9	16.7	
5% level		10.9		8.6	17.2	22.2	

[1] Treated on June 12, 1950 in cement mixer using 0.5% moisture containing 0.1% by weight of methyl cellulose to stick on chemicals.
[2] Planted June 14, 1950. Final emergence counts July 11, 1950.
[3] Refers to germination in field. Official germination 82% (1.25% baldheads, 6.25% abnormal sprouts, 10.5% dead).
[4] Determined from reduction in number of damaged seedlings in treatments as compared with no treatment.
[5] Tetrachloro-para-benzoquinone.
[6] Arasan SF, 75% tetramethyl thiuramdisulfide.

and hypocotyl damage was obtained with dieldrin at the rate of 1 ounce of 25 per cent material per 100 pounds of lima bean seed. The lindane concentrations, 0.33 to 1 ounce of 75 per cent, gave good control; and in this test chlordane gave poor protection.

In another series of experiments presented in table 5 seed was used that had not previously been treated with a fungicide. The liquid fixation method was again used as in the previously discussed tests. Five pounds of seed were treated at a time in this manner. Ten treatments were replicated six times. Each plot was 2 rows wide by 20 feet long, and again one row was dug and the other used for stand counts. Daily counts starting at the time of first emergence indicated no delay in germination by any of the treatments. All of the treatments gave higher total and normal emergence than the untreated check. In all cases the per cent seed germination was higher for the treatments than for the check. Seed and seedling decay seemed higher for certain treatments, but apparently losses from decay were not a limiting factor in these experiments. All of the treatments reduced the incidence of total seed-corn maggot damage to the cotyledons and hypocotyls. Outstanding controls were obtained with aldrin and dieldrin at 2 ounces and 1 ounce of 25 per cent material, respectively, per 100 pounds of seed. Chlordane at a 2-ounce dosage of 40 per cent material, and a combination of lindane at 0.33 ounce and a fungicide, 75 per cent tetramethyl thiuramdisulphide, gave excellent protection. The fungicides alone were also able to alleviate some damage.

DISCUSSION.—In attempting to evaluate the benefit derived from chemical seed treatments in relation to protection of the germinating seeds of lima beans from maggots, it seems that there are a number of variable factors to be considered. Factors that are pertinent in connection with the present investigations can be listed as follows: (1) viability of the seed lot expressed in terms of per cent germination; (2) method of treatment, dosages, and kinds of insecticides or fungicides used; (3) abundance and kinds of seed decay organisms; (4) severity of infestation of the seed-corn maggot; (5) planting conditions: soil temperature, moisture, and pH; and (6) planting practices, such as depth of planting. This list can perhaps be expanded.

The vigor of the seed seems only of consequence in seed lots of wide differences of germinating ability. A difference of only 10 per cent in germination may be offset by other factors. These studies would indicate, however, that seed lots of 60 to 70 per cent germination, or below, should not be treated with insecticides.

The amount of mechanical damage to seed during harvesting may be a factor in certain instances of failure. Seed with a high amount of mechanical damage run through a slurry treater may suffer as a consequence, and in addition maggots are able to enter cracks in the seed without contacting the insecticides. Tests run during 1950 on good seed indicated that the slurry treater reduced germination less than 1 per cent if used correctly. With insecticide treatments it seems desirable to use an adequate fungicide, as most severe maggot damage occurs during cool conditions when germination is retarded.

The 1949 tests are pertinent to the present discussion because not only a seed of low germination was used, but in addition there was a possible dilution of the fungicide (a dry treatment) when the seed was treated again in a slurry treater. It would seem desirable not to combine dry and wet treatments, but to put on both insecticide and fungicide at the same time. Dry treatments are often difficult to handle since often the chemicals are partly lost in the handling of the seed and are not replaced prior to planting. More work is needed concerning the optimum method of seed treatment under all conditions, but it seems that a method of uniformly sticking the chemicals on the seed so that none or little is lost in handling is a desirable feature.

Seed decay and seedling rot caused primarily by low temperature *Pythium* are often severe under low temperature conditions, which favor the development of the fungus over the growth of the plant. Inasmuch as severe maggot injury is also associated with low temperatures, the prevalence of seed decay organisms is often of great importance.

With high populations of the seed-corn

maggot there is evidence that seed treatments will not always afford adequate protection. The great variation in damage from field to field and from week to week introduces a variable that means results of seed treatments must be obtained from a number of fields for more than one season to be highly significant. It is also felt that counting damage to cotyledons above ground is not always a good index of the degree of maggot injury, particularly with light infestations. Digging up seedlings and examining them seems a safer method.

Although maggots cause greater damage to lima beans under conditions of low temperature and high soil moisture, it was found that occasional early plantings were made at soil temperatures too low to obtain emergence in a reasonable length of time. Under these conditions it seemed that chemical seed treatments resulted in greater delay or reduced emergence. The full causes have not been determined.

Certain planting practices, particularly depth of planting, is often a critical factor in rate of emergence, seed decay, and maggot injury. This is particularly true in plot experiments where it is observed that a difference in depth may alter emergence several days. A faster emergence often results in less maggot damage as the seed parts are exposed for a shorter duration of time.

Of the seed treatments mentioned in this paper only one has been used extensively enough to suggest commercial field treatment; this is lindane at 0.33 ounce of 75 per cent formulation (1 ounce of 25 per cent) per 100 pounds of large lima bean seed, together with an adequate fungicide.[4] This dosage is the maximum amount that should be used, and it will also give adequate control of wireworms. In areas of southern California where occasional failures have occurred with the use of lindane, it is best to limit the treatment of large quantities of seed until all the factors can be analyzed. It also appears that dieldrin, aldrin, and chlordane offer possibilities for control as seed treatments, but should be used in limited tests until they can be tried under all conditions and in all lima bean growing areas.

SUMMARY.—This paper presents the results of chemical seed treatments of large lima beans for the control of the seed-corn maggot in the Santa Clara Valley of northern California.

Damage in this area is associated with low soil temperatures, high soil moisture, and a double-cropping practice of alternating lettuce or spinach and beans.

A seed treatment used commercially for seed-corn maggot and wireworm control in this area consists of 0.33 ounce of 75 per cent lindane (or 1 ounce of 25 per cent) with a suitable fungicide such as tetrachloro-para-benzoquinone[5] or tetramethyl thiuramdisulphide.[6] The chemicals are applied as dusts, or as slurries.

During 1949, about 20,000 pounds of large lima beans were treated with the above lindane formulation in this area, and in 1950, 245,700 pounds. No observable adverse effects occurred, and adequate seed-corn maggot protection was obtained.

In experimental trials seed was treated in two ways: (1) by the slurry method; and (2) by liquid fixation, where 0.5 per cent moisture containing a sticker was sprayed onto the seeds previously dusted with chemicals.

Certain laboratory tests indicated that chlordane, aldrin, and dieldrin at the rates specified adversely affected rate of emergence of seed of low germination, but did not affect seed of high vigor.

Field experiments during 1949 indicated a delay in germination with aldrin and dieldrin, but no effect with chlordane. In 1950 these results were not substantiated, and the 1949 results were attributed in part to the vigor of the seed used.

Field experiments during 1950 indicated no delay in emergence using lindane, aldrin, dieldrin, and fungicide combinations, at the rates specified; a fair to excellent reduction in seed-corn maggot injury; and an increase in the number of normal plants with the treatments in comparison with untreated checks.

Factors affecting the use of seed treatments for maggot control include: (1) seed viability; (2) method of treatment, kinds and dosages of chemicals; (3) abundance and kinds of seed decay organisms; (4) severity of maggot infestation; (5) planting conditions; and (6) planting practices.

[4] These fungicides have been tested and seem compatible with lindane.

[5] *Spergon.*

[6] *Arasan.*

Although in this area these seed treatments are economical, effective, and relatively safe, they should not be used in other areas without preliminary trials as some area differences are indicated.[7]

[7] Acknowledgments: The assistance of Professor L. D. Leach in all phases of these seed studies is gratefully acknowledged. Field investigations were made possible through Pictsweet Foods, Inc., and Santa Clara Frosted Foods Co. The assistance of R. Ledum, L. Dannemiller, and G. Piumarta of these organizations is acknowledged. A number of growers cooperated in field experiments including H. Alleman, T. Okeda, and T. Bowers. G. W. Scott and R. M. Moyer furnished seed treating equipment.

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Sodium Selenate Soil Treatments for Chrysanthemum and Carnation Pests

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Selenium was sprayed on plants at least a quarter century ago in an effort to control diseases and insects, but the results were not promising mainly because the compounds used were phytotoxic (Lougee & Hopkins 1925). The use of selenium as a soil treatment for the control of insects and mites probably is an outgrowth of investigations by many workers on the cause of livestock poisoning in the Great Plains States, particularly in South Dakota and Wyoming. Nelson, Hurd-Karrer, & Robinson (1933) found that selenium was assimilated by the grain and straw of wheat. They pointed out that 15 ppm. of selenium in the soil produced chlorosis and stunting of the plants and as little as 1 ppm. was injurious to experimental animals fed on the wheat. Then followed tests with aphids and mites on wheat growing in nutrient solutions containing various levels of selenium (Hurd-Karrer & Poos 1936). These tests disclosed that aphids and mites died within a few days after feeding on plants growing in solutions containing 3 ppm. of selenium. Plants were stunted by solutions containing more than 3 ppm. of selenium.

Neiswander & Morris (1940) found that 1 ppm. of selenium in a nutrient solution kept tomatoes practically free of mites, *Tetranychus telarius* (L.).[2] The growth of tomatoes was retarded and the yield reduced by 2 ppm. The same concentration apparently damaged roses. One variety of carnations grown in selenized soil at levels of 0, 2, 4, 6, 8 and 10 ppm. showed no injury. Likewise, chrysanthemums grown in sand cultures treated with nutrient solutions containing various quantities of selenium up to 2 ppm. showed no injury. Leukel (1940) controlled *Aphis maidis* Fitch and *T. telarius* on sorghum with as little as 2 ppm. of selenium in the soil. The sorghum was stunted by 5, 10, and 15 ppm.

By 1945, Blauvelt had developed the practical use of sodium selenate soil treatments for the control of several greenhouse pests, particularly aphids and mites on chrysanthemums and carnations. He recommended a dosage of 250 milligrams of sodium selenate per square foot of bench area. Kiplinger & Fuller (1946) studied the effects of sodium selenate on a number of greenhouse crops and pests. They found the chrysanthemum varieties Ivanhoe, Jemima, and Jewell sensitive to selenium. They concluded that 250 milligrams of sodium selenate per square foot of soil was the safest and most practical

[1] The author is grateful to George C. Decker, Head of the Section of Economic Entomology of the Natural History Survey, for his interest and support of this work.

[2] Probably recognized now as *T. bimaculatus* Harvey.

dosage for most plants, but suggested two applications 2 to 4 weeks apart, at the rate of one-eighth gram per square foot, for sensitive plants. White & Whitcomb (1946) observed sodium selenate injury to potted carnations and noted the tendency of treated plants to lose their effectiveness against red spider mites. Beach (1947) also observed injury to carnations in gravel culture where sodium selenate was introduced into the nutrient solution. Experiments with various dosages produced stunting that varied from slight to severe.

The above reports suggest the need for quantitative data on the effect of various dosages of sodium selenate on the growth and production of flowers, as well as on pest control. This paper reports data obtained by growing several varieties of chrysanthemums and carnations in soil treated with various quantities of sodium selenate.

A PRELIMINARY EXPERIMENT IN 1946.—A ground bed planted to the pompon chrysanthemum variety Usona was selected for a preliminary experiment to establish procedures and methods. The bed was divided into five 3 by 4-foot plots by board partitions. Each plot contained 20 plants.

The first treatments were made August 10, after the plants had become well established in the soil. The various dosages of sodium selenate[3] were dissolved in about 2 gallons of water and applied uniformly to the soil by means of a watering can with the sprinkler head removed. An equal quantity of water was applied to the check plot at the time treatments were made. The plants received normal greenhouse care.

About 6 weeks before harvest, a heavy infestation of aphids, *Rhopalosiphum rufomaculatum* (Wilson), developed on the check plot, but all of the treated plots were free of aphids. The check plants were so badly damaged by the aphids that the plants became unattractive to them and the population declined before harvest. A count of aphids and mites at harvest time showed a light population of both pests on the check plot but practically no population of either on the treated plots.

There was visible evidence of stunting on plots 2 and 3, which received total dosages of 250 and 375 milligrams respectively per square foot. Plots 4 and 5, which received total dosages of 187.5, and 93.75 milligrams respectively per square foot, showed no evidence of stunting. There was no essential difference in the number of blooms harvested from each of the treated plots but each treated plot produced more than twice as many blooms as the aphid-damaged check plot, table 1.

This experiment indicated the danger of stunting chrysanthemums with sodium selenate, as well as the possibility of growing pest-free plants with low dosages. Accordingly a more comprehensive experiment was set up the next year.

EXPERIMENTS WITH POMPON CHRYSANTHEMUMS IN 1947.—Three varieties of pompon chrysanthemums, Jewell, Uneeda and Revelation were used. Jewell has been reported as being susceptible to sodium selenate injury (Kiplinger & Fuller 1946). Eight plants of each variety were planted in double rows randomized within plots, and the five plots were randomized in each of four ground beds which served as replicates. Hence, a total of 32 plants of each variety received identical treatment. The plants were transplanted from pots to the beds July 10. The plots were separated by 6-inch boards set edgewise about 4.5 inches into the soil.

Records.—When the plants were in suitable bloom for market, they were cut off about 1 inch above the soil for flower counts and stem measurements. The earliest maturing variety, Jewell, was harvested October 23, just 8 days after the second sodium selenate treatment. Therefore, it is doubtful if this variety was affected by the second treatment. Uneeda was harvested December 1 and Revelation January 5.

Results.—All plants in the check plots were severely damaged by the combined attacks of aphids, mites, and mealybugs occurring naturally. In addition, these plants were disfigured by sooty mold. Most of Revelation in the checks died before harvest. None of the treated plots was damaged to any extent by any of the pests.

Data on the mealybug[4] infestation as determined by counts of infested terminal branches are given in table 2. There were

[3] A crystalline product sold widely to the greenhouse trade by the Plant Products Company.
[4] Probably *Phenacoccus gossypii* T. & C.

Table 1.—The effect of sodium selenate on the production of pompon chrysanthemum blooms, variety Usona.

Treatment Dates and Dosage in Milligrams per Sq. Ft. of Soil			Total Milligrams per Sq. Ft.	Blooms Harvested Nov. 26–Dec. 9
Aug. 10	Sept. 12	Oct. 10		
				602
250.			250.	1,397
125.	125.	125.	375.	1,381
62.5	62.5	62.5	187.5	1,318
31.25	31.25	31.25	93.75	1,297

no significant differences among the plots of Jewell. There were no differences among the treatments on Uneeda and Revelation but there were significant differences between check and treated plots.[5] Similar results were obtained on the two-spotted mite, table 2.

A record of the number of flowers harvested showed significant differences between treated and untreated plots for all three varieties, table 3. There were no differences among treatments with Jewell and Uneeda, but with Revelation the number of flowers harvested from the plots treated with 250 milligrams of sodium selenate in a single dose was significantly lower than yields from plots treated with split dosages.

With Jewell, there was no difference in the mean length of plants on any of the plots (Table 3). There were significant differences between treated and untreated plots of Uneeda, but no differences among treated plots. With Revelation, there was striking difference between treated and untreated plots due to severe insect damage to the checks. In addition there was significant shortening of this variety treated with a single 250 milligram dosage.

These data indicate that two treatments 2 months apart with sodium selenate at the rate of 62.5 milligrams per square foot of soil will control chrysanthemum pests without stunting the plants or reducing flower production.

EXPERIMENTS WITH LARGE-FLOWERING STANDARD CHRYSANTHEMUMS.—These experiments were similar in planting and treatment details to those with pompons. Gold, Lode, Marketeer, and Bronze Mistletoe were the varieties chosen for this work. The old soil was removed from the ground beds to a depth of 1 foot and replaced with new soil from a field. The plants were transplanted to the beds on June 16. As with the pompons, eight plants of each variety were planted in double rows randomized within plots and the five plots were randomized in four ground beds. Treatments were made July 14 and September 13, with each dosage of sodium selenate dissolved in about 2 gallons of water.

Records.—As the flowers developed into marketable size and quality, they were cut off at the ground for stem length and blossom size measurements. In addition each plant was given relative ratings of 0, 1, 2, 3, and 4 for aphid and mealybug infestations. Similar ratings were also given for a condition designated as "scorch." This condition was simply a "firing" of the leaves on the lower part of the plant. The mean of these individual ratings was used as the final index. No mite infestation of consequence developed.

Results.—The shorter stem length of plants from the check plots was caused, no doubt, by the heavy aphid infestation.

[5] The author is indebted to J. M. Wright for the statistical analysis of the data in this paper.

Table 2.—The effect of sodium selenate on the mealybug and mite infestations on pompon chrysanthemums.

Sodium Selenate, Milligrams per Square Ft.			Mean No. Branches per Plant Infested with Mealybugs			Mean No. Mites per Leaf		
Aug. 15	Oct. 15	Total	Jewell Oct. 23	Uneeda Dec. 1	Revel. Jan. 5	Jewell Oct. 22	Uneeda Oct. 22	Revel. Oct. 22
			9.3	12.5	[1]	32.2	32.7	40.8
250.		250.	0.7	1.3	2.2	0.1	0.1	0.2
125.	125.	250.	3.1	3.1	4.3	0.0	0.4	0.1
62.5	62.5	125.	2.2	2.8	6.4	0.6	1.2	1.1
31.25	31.25	62.5	3.2	5.3	9.3	2.2	3.5	7.9
Sig. diff. 5% level:			N.S.	6.7	N.S.	N.S.	16.1	26.2

[1] Most of plants killed by pests. Data from this check plot were not sufficient to be included in the analysis, but it was obvious that the treated plots were better than the checks.

Table 3.—The effect of sodium selenate on the production of pompon chrysanthemum flowers and the length of plants.

Sodium Selenate, Milligrams per Sq. Ft.			Flowers[1] per Plant			Length of Plants—Inches		
Aug. 15	Oct. 15	Total	Jewell Oct. 23	Uneeda Dec. 1	Revel. Jan. 5	Jewell Oct. 23	Uneeda Dec. 1	Revel. Jan. 5
			33.5	45.9	0.2	17.1	19.5	2.6
250.		250.	51.6	74.6	41.6	15.8	25.9	24.7
125.	125.	250.	53.7	78.8	55.8	15.8	27.9	30.4
62.5	62.5	125.	54.1	77.5	59.4	17.3	28.5	36.4
31.25	31.25	62.5	54.5	70.4	58.8	17.7	27.5	36.3
Sig. diff. 5% level:			11.3	18.0	9.7	N.S.	4.3	6.3

[1] The sum of open flowers and buds.

No more than one or two plants died in plots planted to Gold Lode and Bronze Mistletoe, but Marketeer appeared more susceptible to aphids and 13 out of the 32 plants died before harvest. Gold Lode, which matured earliest, was not damaged enough by aphids to shorten the stems.

All of the treated plots were free of aphids except the lowest dosage plots of Gold Lode and Bronze Mistletoe. These were slightly infested with aphids, but mealybug control was excellent on all the treated plots (Table 4). It should be mentioned that the insect infestations established themselves naturally and the four untreated checks maintained an insect potential for the treated plots throughout the period of the experiment.

Very little leaf scorch or "firing" of the lower leaves occurred on Bronze Mistletoe but on Gold Lode and Marketeer this condition was much more evident on the treated plots than on the check plots and scorch appeared to increase with the dosage (Table 5).

The stems of Gold Lode and Bronze Mistletoe were shortened by dosages of 0.25 gram per square foot, whether applied at one time or as two one-eighth-gram dosages. Marketeer was not shortened by the treatments, table 6. The slight stunting of these long-stemmed varieties is of no commercial importance.

Because of insect damage the blossoms from the check plots were significantly smaller than those from the treated plots, table 6.

SOIL TREATMENTS WITH SODIUM SELENATE FOR CARNATIONS.—This study was started in 1947 to determine if more efficient sodium selenate schedules could be devised for treating carnations, and to note the effect of these schedules on the plants. The treatment schedules were designed to give dotal dosages of 1,000, 500, 250 and 125 milligrams of sodium selenate per square foot of soil, with applications extending over a 2-year period. It became necessary however, to close the experiment for bench repairs before the last treatment was made. The schedule carried through (Table 7) compares the usually recommended semi-

Table 4.—The effect of sodium selenate on the aphid and mealybug infestations on standard chrysanthemums.

Sodium Selenate, Milligrams per Sq. Ft.			Aphid Infestation			Mealybug Infestation		
			Mean Relative Rating			Mean Relative Rating		
July 14	Sept. 13	Total	Gold Lode	Marke-teer	Bronze M'toe	Gold Lode	Marke-teer	Bronze M'toe
			20.7	14.2	20.5	3.7	4.7	4.0
250.		250.	0.0	0.0	0.5	0.0	0.0	0.0
125.	125.	250.	0.0	0.0	0.5	0.0	0.0	0.0
62.5	62.5	125.	0.0	0.0	0.0	0.0	1.7	0.7
31.25	31.25	62.5	1.5	0.0	2.7	0.0	0.0	0.0

Table 5.—The effect of sodium selenate on leaf scorch of standard chrysanthemums.

Sodium Selenate			Leaf Scorch		
Milligrams per Sq. Ft.			Mean Relative Rating		
July 14	Sept. 13	Total	Gold Lode	Marke-teer	Bronze M'toe
			5.0	7.2	0.7
250.		250.	17.7	19.2	3.5
125.	125.	250.	21.0	17.7	1.5
62.5	62.5	125.	13.2	14.3	0.5
31.25	31.25	62.5	7.5	10.2	1.0

annual 250 milligram treatments with dosages of 62.5, 31.25 and 15.625 milligrams applied every 3 months.

Procedure.—Five plots, each 3.5 by 4 feet, were randomized on each of three raised greenhouse benches which served as replicates. The plots were separated by board partitions extending to the bottom of the benches. The plants were transplanted from pots to the benches on May 7, 1947. The varieties Arundel, Virginia, and Miller's Yellow were planted originally, but because of the plant loss and poor start made by Arundel, this variety was replaced with Seth Parker on July 15. Double rows (10 plants) of each variety were randomized within plots. Thus there were 30 plants of each variety per treatment.

Records.—At intervals throughout the period of the experiment, population counts of the two-spotted mite were made by removing 20-leaf samples from each variety and plot. A motor-driven machine with rotary brushes was used to brush the mites from the leaves onto a glass disk for counting. Observations on the mealybug[6] infestation were made from time to time and each plot and variety was given a relative rating ranging from 0 to 4 depending on the severity of the infestation. The mean of ratings for the three replicates was taken as the mealybug index. No aphid population of consequence developed.

As the flowers were harvested, stem lengths were measured and recorded. The flowers were picked by a grower who had no interest in the outcome of the experiment. The general procedure was to pick the longest stem that the growth and crop outlook would permit. From April, 1948, until the close of the experiment, the diameter of the blossoms was measured with the aid of a calibrated disk.

Results.—Plots 2 and 3, which received the two highest dosages of sodium selenate, were essentially free of mites for over a year, or until August, 1948. After that, the heaviest schedule of treatments (Plot 2) was the only one that satisfactorily kept mites under control (Fig. 1). However, treatments every 3 months with 62.5 milligrams of sodium selenate per square foot of soil afforded good protection from mites and except on susceptible varieties this schedule might work commercially. Under the conditions of the experiment the treated plots were exposed to a high mite potential from the untreated checks, and during the second year the plots treated with the two relatively low-dosage schedules added to the

[6] Probably *Pseudococcus maritimus* (Ehrh.).

Table 7.—Treatment and dosage schedules with sodium selenate used on carnations.

Time and Dosage Rate, Milligrams per Sq. Ft.				No. Treatments 1947–1949	Total Dosage, Milligrams per Sq. Ft.
March	June	Sept.	Dec.		
—	—	—	—	0	0
—	250.	—	0.25	4	1
	62.5			7	7/16
	31.25			7	7/32
	15.62			7	7/64

Table 6.—The effect of sodium selenate on the length of stems and the size of blossoms of standard chrysanthemums.

Sodium Selenate Milligrams per Sq. Ft.			Mean Length of Stems—per sq. ft.			Mean Diameter of Blossoms—Inches		
July 14	Sept. 13	Total	Gold Lode	Marke-teer	Bronze M'toe	Gold Lode	Marke-teer	Bronze M'toe
			43.3	44.9	68.6	4.5	0.0	4.6
250.		250.	41.8	52.6	70.1	5.4	5.8	6.6
125.	125.	250.	41.1	50.9	68.7	5.2	5.8	6.5
62.5	62.5	125.	45.1	54.4	72.0	5.7	5.9	6.6
31.25	31.25	62.5	45.8	54.7	72.9	5.9	5.5	6.7
Sig. diff. 5% level:			3.2	N.S.	2.5	0.5	0.1	1.2

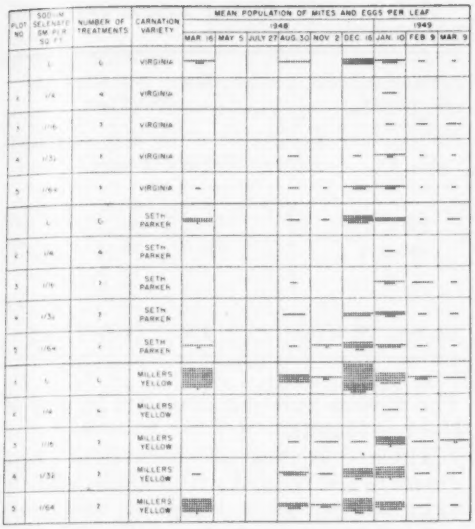

FIG. 1.—The effect of sodium selenate treatments on the population of mites and eggs on carnations for the two-year period of the experiment. Each dot represents one egg or mite.

over-all mite potential. Miller's Yellow was the most susceptible of the three varieties to mite damage and Virginia the least susceptible.

Mealybugs appeared to prefer Seth Parker, the most vigorous grower of the three varieties. The relative effectiveness of the four schedules in controlling mealybugs was essentially the same as in controlling two-spotted mites. Mealybug ratings taken March 17, 1949, near the close of the experiment, indicate good control with four one-fourth-gram treatments and substantial control with seven one-sixteenth-gram treatments (Table 8). Seven one-thirty-second-gram and one-sixty-fourth-gram treatments did not maintain mealybug control.

The per cent of plants surviving until the close of the experiment shows a very good correlation between the dosage schedules and the damage caused by the combined attacks of mites and mealybugs (Fig. 2.)

Effect of Sodium Selenate on the Carnations.—The data in table 9 indicate that even the highest dosage schedule of sodium selenate did not reduce flower production. In fact, all three varieties considered, plots receiving four one-fourth-gram treatments were the highest producers. This appears to be tied in with pest control and the lower yields on the other plots are, no doubt, a manifestation of pest damage and plant loss.

The stems of Virginia and Seth Parker were significantly shortened by all four of the sodium selenate treatment schedules (Table 10). The stems of Miller's Yellow were significantly shortened by only the two heaviest dosage schedules. The stems from plots receiving four 250-milligram dosages were from 4 to 8 inches shorter, varying with the variety, than stems from untreated checks. Stems from plots receiving seven 62.5 milligram treatments were considerably longer than those from plots severely stunted with four 250 milligram dosages and were somewhat shorter than stems from the lower-dosage plots, which were only slightly stunted.

Sodium selenate did not have much effect on the size of the blossoms, table 10. There were no differences among the plots of Miller's Yellow and Virginia. Seth Parker blossoms from the check plots were significantly smaller than flowers from the plots receiving 15.6, and 31.25, milligrams of sodium selenate per treatment.

SUMMARY AND CONCLUSIONS.—A pre-

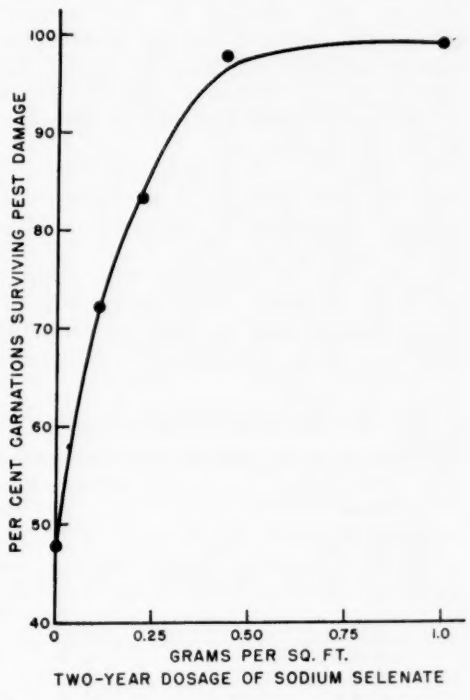

FIG. 2.—The relationship between sodium selenate dosages and the per cent of carnations surviving pest damage.

Table 8.—Relative mealybug infestation rating on carnations in tests with sodium selenate soil treatments.

Sodium Selenate, Mgms. per Sq. Ft.	No. Treatments	Relative Mealybug Rating		
		Virginia	Seth Parker	Miller's Yellow
	0	1.0	3.7	2.5
250.	4	0.7	0.0	0.3
62.5	7	0.3	1.0	0.3
31.25	7	1.7	1.7	1.0
15.6	7	2.0	3.0	0.5

Table 9.—The effect of sodium selenate on carnation flower production.

Sodium Selenate, Mgms. per Sq. Ft.	No. Treatments	Mean No. Flowers per Plant		
		Virginia	Seth Parker	Miller's Yellow
	0	8.4	20.4	13.4
250.	4	20.5	20.5	18.7
62.5	7	16.3	22.9	16.3
31.2	7	14.9	19.8	16.1
15.6	7	11.9	19.3	15.4
Sig. diff. 5% level:		5.2	N.S.	N.S.

liminary experiment in 1946 with one variety of chrysanthemum indicated the danger of stunting plants with sodium selenate as well as the possibility of growing pest-free plants by using low dosages.

Three varieties of pompon chrysanthemums, Jewell, Uneeda, and Revelation, were kept almost completely free of aphids, mealybugs, and mites by treating the soil with sodium selenate once at the rate of 250 milligrams per square foot and twice at rates of 125, 62.5 and 31.25 milligrams per square foot. Neither the flower production nor the length of the two earlier-maturing varieties, Jewell and Uneeda, was affected by the sodium selenate treatments, but the flower production and the length of Revelation appeared to be adversely affected by a single treatment at the rate of 250 milligrams per square foot.

Excellent control of aphids and mealybugs was also obtained at all dosage levels on three large-flowering standard varieties of chrysanthemums, Gold Lode, Marketeer, and Bronze Mistletoe. The stunting of these varieties with the 250 milligram dosages was so slight it probably would be of no commercial consequence. The flowers were not damaged by any of the treatments.

Three varieties of carnations were grown in soil treated with sodium selenate twice a year at a dosage of 250 milligrams per square foot and four times a year at dosages of 62.5, 31.25 and 15.6 milligrams per square foot. All treatments maintained some degree of pest control and the two higher-dosage schedules maintained satisfactory pest control for over a year. After the first year only the semiannual 250-milligram dosage produced essentially pest-free plants of all three varieties.

Pest damage reduced carnation flower production substantially but the sodium selenate treatments had no effect on the size and number of flowers produced. On the other hand, all treatments except the lowest dosage shortened the stems of carnations. Rather severe stunting resulted from the higher dosage levels.

It may be concluded that sodium selenate soil treatments appear to be more satisfactory for pest control on chrysanthemums than on carnations. By using low split-dosages of sodium selenate it

Table 10.—The effect of sodium selenate treatments on the length of stem and the size of carnation flowers.

Sodium Selenate, Milligrams per Sq. Ft.	No. Treatments	Mean Length of Stems—Inches			Mean Diameter of Flowers—Inches		
		Virginia	Seth Parker	Miller's Yellow	Virginia	Seth Parker	Miller's Yellow
	0	16.8	24.5	26.0	2.17	2.50	2.40
250.	4	12.6	16.1	19.5	2.27	2.57	2.40
62.5	7	14.7	20.4	23.4	2.37	2.70	2.40
31.2	7	15.5	23.2	24.7	2.27	2.77	2.43
15.6	7	15.9	23.3	24.9	2.33	2.77	2.40
Sig. diff. 5% level:		0.7	1.2	1.5	N.S.	0.23	N.S.

appears possible to grow pest-free chrysanthemums with little, if any, stunting or other damage.

Pest control on carnations with sodium selenate soil treatments is difficult to maintain for more than a year without using a dosage schedule that stunts the plants. By accepting some stunting it appears that some varieties can be kept essentially pest-free for 2 years by treating the soil every 3 months with sodium selenate at the rate of 62.5 milligrams.

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Some Hyphomycetous Fungi Found on Insects in the Pacific Northwest

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The most common entomogenous fungus of a hyphomycetous form found by the writer in the Pacific Northwest was a species of *Beauveria*, probably *B. bassiana* (Bals.) Vuill. A specimen cultured from the clover root borer, *Hylastinus obscurus* (Marsh.), was determined[2] as *B. bassiana* (*globulifera* by Vera K. Charles.[3] Miss Charles (1941) listed *B. bassiana* (Bals.) Vuill. on this species in Oregon and also on *Bruchus pisorum* (L.) in Oregon and on *Dyslobus decoratus* (Lec.) in Washington. She also listed *B. globulifera* (Speg.) Pic. from Staphylinidae and from *Galerucella xanthomelaena* (Schr.) in Washington.

Most of the spores of the *Beauveria* found on various insects in the Pacific Northwest are spherical. According to Petch (1926), this characteristic would throw the species out of *B. globulifera*, which this fungus has often been called in the United States. Spores germinated in hanging drop cultures showed the characteristics of *B. bassiana* as described by Lefebvre (1931).

The length of the mycelium produced on the insects and on culture media, even when the material was from the same original source, varied considerably. In nature, the location of the insect at the time of death from fungous infection has a good deal to do with this, as specimens in concealed locations, such as clover root borers in mines in the roots, produced longer mycelium, often in the form of coremia, than did exposed specimens. In cultures, coremia often grew up the walls of the culture vessel. Some years ago, while working in a laboratory at Salt Lake City, Utah, the writer infected both living and killed alfalfa weevils with this fungus (Rockwood 1916). In these experiments the weevils that had been killed before infection showed a long, thin, cottony growth of mycelium with scattered spore balls, whereas those that had died from fungous infection showed the typical short, matted mycelium thickly covered with a mealy coating of spore balls.

In October 1922 three *Sitona hispidula*

[1] Retired October 31, 1948.
[2] April 2, 1936.
[3] Formerly of the Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils and Agricultural Engineering, U.S.D.A.

(F.) beetles that had just died of fungous infection were buried in soil in glass vials before any exterior growth of the fungus. The vials were placed in a dark cellar and forgotten for many months. When examined in 1923, the fungus had produced long, string-like strands of anastomosed hyphae, with a brownish exterior, which grew far out of the soil. It seems possible that if the containers had been placed in a well-lighted place, these strands might have thickened into the short, headless *Cordyceps*-like growths that the writer once saw on a specimen of the same species of insect sent to him by C. M. Packard from Hagerstown, Md., in August 1914.

The writer believes that there is one pleophagus species of *Beauveria* in the Northwest that can be distinguished from another common white fungus, *Spicaria gracilis*, by the mealy covering of globose spore balls. This fungus, as recognized by the writer, has been found on many ground-frequenting insects of which the following, besides those already mentioned, were noted: *Brachyrhinus* spp., *Hypera punctata* (F.), *H. nigrirostris* (F.), *Hippodamia* spp., *Diabrotica undecimpunctata* Mann., carabids, staphylinids, *Peranabrus scabricollis* (Thos.) from Washington, noctuid larvae, and spiders. In the fall and spring, large numbers of *Sitona hispidula* beetles become infected by this fungus—as many as 20 per cent of a large field sample in March 1937. Often considerable numbers of the overwintered, gravid females of *Diabrotica undecimpunctata* are similarly affected (Rockwood & Chamberlin 1943).

It is probable that this fungus would show strains that are more virulent to some insects than other strains. In fact, a strain from a staphylinid beetle was distinctly less virulent to *Diabrotica undecimpunctata* beetles in parallel infection experiments than a strain from a carabid beetle.

Another common white species was identified as *Spicaria gracilis* Petch (Petch 1931) by Miss Charles.[2] In one case on a carabid beetle, both *S. gracilis* and *Beauveria bassiana* occurred together, whereas another carabid collected at the same time showed only *B. bassiana*. *S. gracilis* is often found on hibernating pea weevils. It has also been observed on pupae of an arctiid and *Autographa californica* (Speyer). On the insect this species forms a pure white, short cottony covering and the sporiferous layer is finely pulverulent and pure white, whereas *B. bassiana* takes on an ivory tint when the mealy sporiferous layer develops. *S. gracilis* was not observed to develop coremia as do the species of *Spicaria* that were formerly placed in the genus *Isaria*. It appears to be of a low virulence to insects and may be able to infect only insects that are in a weakened condition.

In April 1933 comparative infection experiments were conducted in the laboratory with *Diabrotica undecimpunctata* beetles that had been culled for disease for 10 days. In these experiments *Beauveria bassiana*, originally from a carabid beetle in 1932, killed 80 per cent of the beetles in 18 days. *Spicaria gracilis*, originally from a pea weevil in 1932, developed on 46 per cent of the beetles in 30 days in the series infected with that species. In 1936 *D. undecimpunctata* beetles, culled for disease between January 20 and March 5, were used in another comparative infection experiment. All the beetles in the cage infected with *B. bassiana* (originally from clover root borer) died of this disease in 11 days, and all but one died in a cage infected with *Metarrhizium brunneum* Petch in 2 weeks. In the parallel series with *Spicaria gracilis*, 3 beetles out of 10 survived for 3 weeks.

A secondary fungus, which was parasitic on *Beauveria bassiana*, was discovered in October 1932 on a hibernating adult *Hippodamia sinuata spuria* Lec. and, later, on *Spicaria gracilis* on a hibernating pea weevil, *Brunchus pisorum* (L.). This fungus could be transferred to young cultures of either of the fungi just mentioned (before spore development) when these were inoculated with the spores of the parasitic fungus. The fungus grew on the mycelium of the host fungus and prevented spore formation. It appeared as dark bristle-like projections on the white mycelium of the host fungus. These projections were the necks of the brown perithecia, which were bulbous and so firmly attached to the host mycelium by root-like mycelial strands that a tuft of the host mycelium clung to them when pulled out. As the perithecia ripened, the necks matured and the asci released the spores that came up through the bore of the neck and accumulated in bunches, which ad-

hered to the tips of the necks. This fungus appears to agree with *Melanospora parasitica* Tul., which Petch (1925) found on *Cephalosporium* on scale insects.

In cultures made directly from fungus-covered insects (clover root borer, *Diabrotica undecimpunctata*, and *Brachyrhinus* sp.), a species of *Cephalosporium* sometimes developed on *Beauveria bassiana* or on *Spicaria gracilis* (from pea weevil), covering the primary fungus with a fine, faintly yellowish, cottony growth of mycelium that seemed to greatly reduce the formation of spores of the primary fungus. Forms that were also probably a species of *Cephalosporium* were observed in nature on aleyrodid pupae and aphids collected on the undersides of leaves in a cold, damp canyon (Clear Creek) in the eastern foothills of the Coast Range and on the seacoast near Coquille, Oregon. A species of *Cephalosporium* was also observed on dead grasshopper eggs, *Camnula pellucida* Scudd., from the Upper Klamath Marsh in south-central Oregon, and on sugar-beet wireworms, *Limonius californicus* Mann. from Parma, Idaho. A pretty little *Aspergillus*, which answers to the description of *A. depauperatus* Petch (1931), was found on aphids in the above-mentioned cold, damp canyon. It is doubtful if these forms are actually parasitic on insects.

A common species on the many spiders of the seacoast region, west of the Coast Range, answers to the description of *Gibellula aranearum* (Schw.) Syd. (*G. arachnophila* Vuill.) (Veuillemin 1910). East of the divide of the Coast Range, it was found in the above-mentioned Clear Creek Canyon only. This species produces many white club-shaped coremia, on the heads of which the pale lilac-colored spores are produced. It is probable that this species is pathogenic to spiders.

Two species of *Metarrhizium*, *brunneum* Petch and *anisopliae* (Metsch.) Sor., were found in the Pacific Northwest, but these will be taken up in a separate paper.

Spicaria rileyi (Farlow) Charles, the fungus that commonly attacks lepidopterous larvae in the Eastern States, was not found in the Pacific Northwest. The writer secured some material of this fungus through the kindness of J. W. Wilson, of the Florida Agricultural Experiment Station, and from F. F. Dicke, of the Bureau of Entomology and Plant Quarantine. This species was observed in culture in comparison with the common native species, *Beauveria* spp., *Metarrhizium* spp., and *Spicaria gracilis*. *S. rileyi* needed a temperature above 70° F for normal development, whereas the other species grew readily at temperatures in the 50's. In the Pacific Northwest outdoor temperatures in excess of 70° usually occur only during the dry summer. Hence it is probable that *S. rileyi* cannot thrive there. The fungus readily killed lepidopterous larvae in the laboratory, but it rarely developed normally on them at room temperatures in the spring and early summer. An attempt was made to introduce this fungus into Coos County on the Oregon seacoast, but it is doubtful whether the fungus would thrive there as the summers, while humid, are cool. *S. rileyi* cultures retained their viability for 5 years or more; those of the other species were all dead after 2 years.

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Mist Sprays for Control of Certain Truck Crop Insects[1]

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During 1947, 1948, and 1949 low-volume concentrated sprays were applied in the form of mists to several truck crops in the vicinity of Kenosha, Wis., and found to be just as effective against several species of insects as conventional high-volume sprays. A specially designed mist blower was used. As the mist blower is lighter in weight than conventional spray equipment and reduces the water-hauling problem to a minimum, this method of application appears very promising.

In 1947 and 1948 the mist sprays were applied by means of an improvised mist blower fitted with four air outlets which covered a swath 12 feet wide. Each outlet was 2.25 inches in diameter. To provide the air blast, the blower fan of a power duster was hooked up with a 5-hp. gasoline motor and operated at 3200 r.p.m. The insecticide was sprayed into the air stream at a pressure of 20 pounds per square inch as it left each outlet through a single, small-capacity, whorl-jet angle nozzle which produced a hollow-cone spray. This equipment did not provide sufficient air volume or air velocity to adequately break up and distribute the spray.

In 1949 a new and greatly improved mist blower was employed (Fig. 1). The air blast is generated by an 18-inch radial blower fan driven at 2200 r.p.m. by a 20-hp. gasoline motor, and delivers 3500 cubic feet of air per minute at an initial velocity of 5500 feet per minute. Four fishtail air outlets with 24- by 2.25 -inch openings distribute the air over a 20-foot swath. The insecticide is introduced into the air stream at a pressure of 75 pounds per square inch as it leaves each outlet through two small-capacity T-jet, straight nozzles, similar in performance to those used on the previous machine. The assembly is mounted on a two-wheeled rubber-tired cart and drawn by a small tractor. All mist sprays were applied at the rate of 10 gallons per acre, except that in 1949 in the experiment on potato the rate was 12 gallons per acre.

Results of similar experiments with the mist blower against the pea aphid, *Macrosiphum pisi* (Kltb.), are presented in a separate paper (Bronson & Dudley 1950).

Experiments on Potato.—Experiments were conducted in all three years for control of the potato leafhopper, *Empoasca fabae* (Harr.), and the potato flea beetle, *Epitrix cucumeris* (Harr.). For comparison with the mist blower, a conventional 4-row tractor-powered sprayer applied sprays at the rate of 100 to 120 gallons per acre at a pressure of 250 pounds per square inch through standard high-gallonage, hollow-cone nozzles. DDT wettable powder was employed as the insecticide, and tribasic copper sulfate as the fungicide. The plots ranged from 0.033 to 1 acre, and treatments were replicated four times. From five to seven applications were made in different tests, and the infestation was determined from 2 to 4 days after each application by making eight sweeps with a standard 15-inch insect net in the center rows of each plot. Yields were determined in the larger plots by harvesting alternate rows and in the smaller plots by harvesting the entire plot. Results of the experiments are shown in table 1.

Table 1.—Comparison of mist sprays with conventional sprays against leafhoppers and flea beetles on potato.

Method of Application	Pounds of DDT per Acre	Seasonal Average Number of Insects per 8 Sweeps		Yield of Tubers, in Bushels per Acre
		Leafhoppers	Flea Beetles	
		1947—Test No. 1		
Mist blower	.5	6	18	341
	1	1	5	348
	2	1	2	363
Conventional	.5	3	24	334
		1947—Test No. 2		
Mist blower	.5	9	31	338
	1	8	22	358
Conventional	.5	5	23	318
		1948		
Mist blower	.5	4	26	234
Conventional	.5	4	10	249
		1949—Test No. 1		
Mist blower	.75	14	10	411
Conventional	.75	19	12	412
		1949—Test No. 2		
Mist blower	1	7	2	510
Conventional	1	7	3	512

When the same amount of DDT was

[1] In cooperation with the Wisconsin Agricultural Experiment Station.

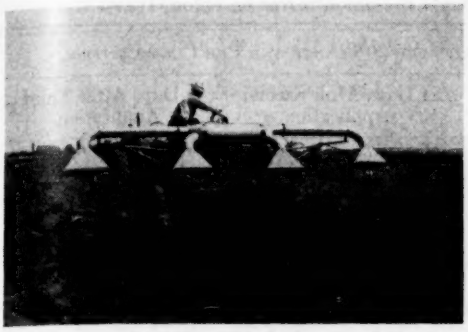

FIG. 1.—Improved mist blower applying insecticides to carrots.

applied per acre, the two methods of application appeared equally effective in controlling the two species of insects. As no plant diseases developed in the experimental plots, the effectiveness of the mist blower for control of diseases was not determined. Some difficulty was experienced with clogging of the nozzles of the mist blower, but it was probably caused by the tribasic copper sulfate, because no clogging resulted in other experiments when only DDT wettable powder was used. It would seem desirable to use a liquid fungicide when applying such small quantities of spray as 10 gallons per acre.

EXPERIMENTS ON CABBAGE.—Experiments were conducted in 1948 and 1949 for control of three species of caterpillars —the imported cabbageworm, *Pieris rapae* (L.), the cabbage looper, *Trichoplusia ni* (Hbn.), and the diamondback moth, *Plutella maculipennis* (Curt.). For comparison with the mist blower a conventional 4-row tractor-powered sprayer was used to apply sprays at the rate of 100 to 120 gallons per acre at 250 pounds pressure.

1948 Experiment.—Mist sprays were applied with the original 12-foot mist blower. Plots four to eight rows wide and 20 to 40 rods long were laid out in commercial plantings, and treatments were replicated from three to six times. DDT wettable powder was the insecticide used. Infestation counts were taken two to four days after each application on 20 plants in each plot. The imported cabbageworm was more abundant than the other two species, averaging 63 per cent of the total infestation in four fields. The effectiveness of the treatments was determined by selecting plants shown by feeding injury to have been infested at the time of treatment. Where it was not possible to leave untreated checks, the per cent control was based on pretreatment counts. The results of the experiment are presented in table 2. As there was little difference in control of the different species, the table shows the total number of all three species.

Table 2.—Comparison of mist sprays with conventional sprays against three species of caterpillars on cabbage, 1948.

METHOD OF APPLICATION	POUNDS DDT PER ACRE	CATERPILLARS PER 20 PLANTS	PER CENT CONTROL
	Test No. 1		
Mist blower	.75	10	91
Conventional	.75	18	83
Check, untreated	—	108	—
	Test No. 2		
Mist blower	.5	2	98
Conventional	.5	2	98
Check, untreated	—	92	—
	Test No. 3		
Mist blower	.5	7	92
Conventional	.5	11	87
Pretreatment count	—	84	—
	Test No. 4		
Mist blower	.5	5	96
Conventional	.5	11	91
Pretreatment count	—	124	—

Both the mist spray and the conventional spray gave good control of the caterpillars. Some of the imported cabbageworms had burrowed into the developing head by the time of treatment and were thus partially protected from the spray. The mist spray appeared somewhat more effective against the protected caterpillars than the conventional spray, but the differences were slight.

1949 Experiment.—In 1949 the improved mist blower was employed. It cov-

Table 3.—Effectiveness of DDT at 1 pound per acre in mist sprays for controlling onion thrips on onion, 1948.

FORMULATION	THRIPS PER 10 PLANTS, AVERAGE		BUSHELS NO. 1 ONIONS, PER ACRE
	August 3	August 10	
Wettable powder suspension	29	34	388
Methylated naphthalene emulsion	22	20	—
Check, untreated	202	488	319

Table 4.—Effectiveness of mist sprays against the onion thrips on onion, 1949.

Formulation	Pounds Toxicant per Acre	Number of Thrips per 20 Plants and Per Cent Control					
		2 Days After First Application		4 Days After Second Application		4 Days After Third Application	
		Thrips	Control	Thrips	Control	Thrips	Control
DDT-xylene emulsion	1	2	85	15	88	6	94
Parathion suspension	.25	1	92	11	91	6	94
Check, untreated	—	13	—	125	—	101	—

ered a swath 6 rows wide. The infestation was determined as in 1948, except that only 10 plants per plot were used for the count of caterpillars. DDT wettable powder was used in two tests, 0.5 pound of DDT per acre being applied by each method. In the first test a count made 1 day after application showed the mist spray to be slower acting than the conventional spray. A count made eight days after application showed 98 per cent control for the mist spray and 99 per cent for the conventional spray. In the second test a count made 4 days after application showed 94 per cent control by each method. The mist spray, therefore, appeared as effective as the conventional spray for control of caterpillars on cabbage.

EXPERIMENTS ON ONION.—Experiments were conducted in 1948 and 1949 for control of the onion thrips, *Thrips tabaci* (Lind). On account of the narrow rows it was not possible to use the conventional sprayer on this crop for comparison with the mist blower.

1948 Experiment.—Plots 12 feet wide and 20 rods long were laid out in a small field of Sweet Spanish onions. DDT was applied at the rate of 1 pound per acre by means of the original 12-foot mist blower, and treatments were replicated three times. In the first treatment a 50-per cent DDT wettable powder plus a small amount of wetting agent was employed, and in the second treatment a DDT emulsion containing a methylated naphthalene solvent was used. It was not possible to provide more than one check plot for this test. Applications were made on August 2 and 9, and the infestation was determined 1 day after each application by counting the thrips on each of 10 plants selected at random in each plot. Yields were determined in the plots receiving wettable powder and in the check plots by harvesting six full rows in each plot. No yield records were taken from the emulsion-treated plots. The results are shown in table 3.

Both DDT wettable powder and DDT emulsion mist sprays were highly effective in reducing the number of thrips one day after application. The DDT wettable powder gave an increase of 69 bushels per acre, or 23 per cent over the untreated check.

1949 Experiment.—In 1949 mist sprays were applied with the improved mist blower. DDT was applied in the form of a xylene emulsion at the rate of 1 pound per acre. Parathion was applied as a suspension at the rate of 1 pound of a 25-per cent wettable powder per acre. Infestations were determined 2 or 4 days after each application by counting the thrips on 20 plants selected at random in each plot. Yield records were not taken. The results are shown in table 4.

Both DDT and parathion were highly effective in reducing the number of thrips. Observations indicated that insecticide drift reduced the infestation in some of the check plots.

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Duration of the Effectiveness of Lead Arsenate Applied to Turf for White Grub Control

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For a number of years white grubs have been a constant source of injury to grass in lawns, parks, cemeteries and golf courses throughout much of the eastern half of Ohio and to a lesser extent in the western half. Two types of grubs have been responsible for the damage, the *Phyllophaga* grubs, of which several species are involved, and the northern masked chafer, *Cyclocephala borealis* Arrow.

The *Phyllophaga* or common white grubs have essentially a 3-year cycle in the state and as a result are most destructive every third year although some injury may appear any year. The most pronounced injury from these grubs has occurred during the years 1935, 1938, 1941, and corresponding years. Consequently it is the "C" brood that has been causing the major damage in Ohio. It should be stated, however, that in recent years a realignment of the three broods seems to be taking place. For instance in 1946 and 1949 the *Phyllophaga* beetle flight was greatly reduced from what it had been during the 1930's and early 1940's. Likewise the grub damage in 1947 and 1950 was also much less than it had been at corresponding stages of earlier cycles of the insect.

The *Cyclocephala* grubs have a 1-year cycle and consequently may appear every year. However, this species also was less abundant during the years 1945 to 1948 than it had been previously, although in 1949 and 1950 it has again shown a tendency to accumulate.

In 1935 an experiment was started on the control of white grubs with lead arsenate on the experiment station grounds in an area where grubs of both groups occasionally become abundant. The experiment was originally set up with five treatments each replicated eight times (1937). Later, because of the encroachment of trees along one border, two of the replicates were eliminated. Consequently, in this paper the mean data were obtained from eight replicates during the period 1935 to 1945 and only six since that time. The experimental unit consisted of a plot 10 feet square.

The experimental area was cultivated, leveled off, and arranged in the required number of plots with the treatments randomized within the eight blocks. The required amount of lead arsenate was broadcast on each plot and mixed with the upper surface of soil by raking with a hand rake. The levels of lead arsenate used were 0, 5, 10, 20, and 30 pounds per 1000 square feet of surface. The entire area was then seeded using a mixture of three parts bluegrass, one part redtop, and one-fourth part white clover, applied at the rate of 4 pounds to 1000 square feet of surface, and covered lightly by hand raking. The grass grew well and eventually formed a fairly uniform sod. Since 1935 no materials of any kind have been added to the experimental area and the only disturbance has been the occasional sampling for grub population and for arsenic content. Each year the grass has been clipped regularly in accordance with the usual lawn practice.

The soil on which this experiment was conducted is known as Wooster silt loam. It is a glacial sandstone and shale soil of a brown to grayish-brown color with a light textured sub soil and good natural drainage. The plots were located on a slight slope and during heavy rains there was some movement of water across the plots. This probably accounts for the early accumulation of lead arsenate in the untreated check plots.

Since 1935 white grubs have been sufficiently abundant to justify taking records in 9 of the 15 years that have elapsed. Fortunately, those years in which population records were taken were distributed fairly well throughout the 15-year period, so that any important change in effectiveness over the period of years could be shown.

As could be expected the *Phyllophaga* and *Cyclocephala* grubs varied in their relative abundance from year to year. In some years one group predominated and in other years the other group was most abundant. But since the two types of grubs frequently occurred together, and inasmuch as the response to the arsenical treatment was similar, the grubs of the

Table 1.—White grub population in 1937 following lead arsenate treatment in 1935.

Pounds Lead Arsenate per 1000 Sq. Ft.	Grubs Recovered per Plot Sample								Mean	Per Cent Control
	R1	R2	R3	R4	R5	R6	R7	R8		
0	21	6	8	6	7	3	6	6	7.9	
5	0	0	0	0	0	0	0	2	.2	97.5
10	0	0	0	0	0	0	0	0	0	100
20	0	0	0	0	3	0	0	0	.4	94.9
30	0	0	0	0	0	1	1	1	.4	94.9

two genera are not differentiated in this report.

Grub population records were obtained in the fall before movement downward had started. In taking the grub population five samples, 8 inches in diameter, were taken to a depth of 6 inches in each plot. The soil was run through a quarter-inch-mesh screen made of hardware cloth and the total grubs obtained recorded for each plot. In this manner a total of 30 samples involving a little more than 10 square feet of soil was examined from each treatment.

In order to show the nature of white grub distribution as well as the variation in the effectiveness of the treatments, the complete data for all replicates are given for the years 1937 and 1943 in tables 1 and 2.

It may be noted from table 1 that all lead arsenate treatments were highly effective in 1937, and no one treatment was any more or less effective than any other. In 1943, on the other hand, the lower arsenic levels had lost some of their effectiveness (Table 2). In that year the 5-pound level had reduced the grub population by only 50 per cent and only the 30-pound level had reduced it more than 90 per cent.

The mean values for each treatment for all 9 years that records were taken are shown in table 3.

In order to ascertain whether the decrease in effectiveness was continuous throughout the period of investigation, all grub population data were combined by 5-year periods by taking the average grub population for the total number of years in which data were taken in each of the three 5-year periods that have elapsed since the experiment was started. Fortunately the 9 years in which grub population data were taken were distributed in such a way that there were at least 2 years of data in each 5-year period. The mean grub population for all lead arsenate levels in each of the three periods is shown in table 4, and the average per cent reduction in grub population for each level and each period is shown in table 5.

A casual review of the data in tables 4 and 5 will show that only the 30-pound level maintained its original effectiveness throughout the three 5-year periods. The 20-pound rate maintained its effectiveness through the second 5-year period but in the third 5-year period it was only equal in effectiveness to that of the 5-pound rate during the first 5-year period.

At intervals soil analyses[1] were made for arsenic content. Ten borings to a depth of 6 inches were made with a soil

[1] The soil analyses were made by Lawson Stoneburner, Wesley Stoneburner, and E. E. Barnes all of the Agronomy Department of the Ohio Agricultural Experiment Station.

Table 2.—White grub population in 1943 following lead arsenate treatment in 1935.

Pounds Lead Arsenate per 1000 Sq. Ft.	Grubs Recovered per Plot Sample								Mean	Per Cent Control
	R1	R2	R3	R4	R5	R6	R7	R8		
0	16	10	10	7	14	26	24	20	15.9	
5	5	3	6	6	5	10	14	14	7.9	50.3
10	1	1	0	0	6	6	6	4	3.0	81.1
20	0	1	2	0	4	2	1	3	1.6	89.9
30	1	0	1	0	1	0	0	1	.5	96.9

Difference required for significance at 5 per cent level 4.4.

Table 3.—Mean grub population by treatments for years in which records were taken.

Pounds Lead Arsenate per 1000 Sq. Ft.	Mean Number of Grubs per Plot Sample by Years								
	1937	1938	1939	1940	1941	1942	1943	1946	1947
0	7.9	3.1	4.1	5.2	2.2	13.1	15.9	3.2	7.3
5	.2	1.2	0	3.9	2.2	4.0	7.9	2.0	4.5
10	0	.4	.1	1.0	.5	.6	3.0	1.5	2.7
20	.4	.2	0	1.1	.1	0	1.6	.8	2.0
30	.4	.4	0	0	0	.4	.5	.2	0

auger in each of six replicates for each treatment. However, the borings obtained from replicates 1 and 2, 3 and 4, and 5 and 6 were then combined and composited to give three samples from each treatment for analysis. The analyses were made in 1938, 1940, 1943, and 1947. The mean results are shown in table 6, for all of the years in which analyses were made.

A study of the data in table 6 shows there apparently was a movement of the lead arsenate from the treated area to the untreated check plots. The 1938 values for the 5-pound and the 30-pound levels are definitely out of line in that the amounts recovered in 1938 were considerably higher than the amounts applied in 1935. These abnormalities are undoubtedly due to error in distributing the arsenic in 1935 or in sampling the soils in 1938. Nevertheless the data as a whole show that there was a marked decrease in arsenic content in all levels over the period of the investigation. The decrease in arsenic content serves to explain the gradual decrease in the effectiveness of the various treatments over the years.

Table 4.—Average annual grub population by 5-year periods following treatment in 1935.

Pounds Lead Arsenate per 1000 Sq. Ft.	Average Number Grubs Recovered per Plot Sample		
	1935–40	1941–45	1946–50
0	5.1	10.4	5.2
5	1.3	4.7	3.2
10	.4	1.4	2.1
20	.4	.6	1.4
30	.2	.3	.1

Table 5.—Average per cent grub control by 5-year periods following treatment in 1935.

Pounds Lead Arsenate per 1000 Sq. Ft.	Per Cent Reduction from Check Plots		
	1935–40	1941–45	1946–50
5	74.5	54.8	38.5
10	92.2	86.5	59.6
20	92.2	94.2	73.1
30	96.1	97.1	98.1

Table 6.—Arsenic content of soil in pounds per 1000 square feet.

Applied in 1935	Arsenic Recovered in				Value of b[1]
	1938	1940	1943	1947	
0	2.9	.8	1.4	.6	.19
5	10.8	6.0	2.4	2.4	.88
10	11.8	8.7	6.5	3.9	.84
20	19.2	18.0	10.2	5.9	1.59
30	48.4	28.7	19.1	9.1	4.04

[1] Slope of line represents loss in pounds arsenic content per year.

SUMMARY.—Lead arsenate applied to the soil in 1935 at levels of 5, 10, 20, and 30 pounds per 1000 square feet was highly effective in controlling white grubs at all levels through the first 5-year period. In the two succeeding 5-year periods the 30 pound level continued to maintain its original effectiveness, but all other levels showed a gradual decline

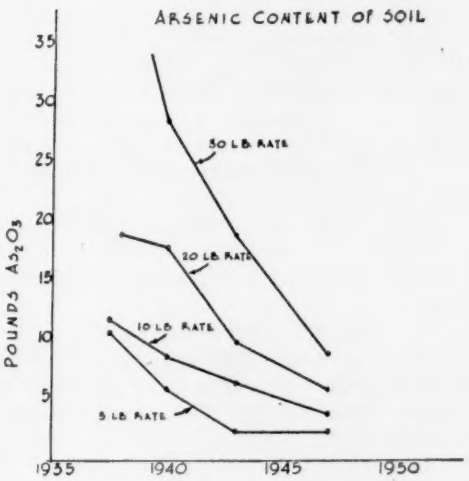

FIG. 1

in white grub control. Soil analyses made at intervals showed a corresponding decline in arsenic content, but the arsenic content of the soil at the 30-pound level was still high enough in 1947 to give a very high degree of control.

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Octamethylpyrophosphoramide

PHILIP P. WALLACE[1]

Widespread interest in plant systemic insecticides followed the disclosure of investigations by Schrader (1948). Although the idea and practice of using chemicals that are absorbed by plants, rendering their tissues toxic to insects that feed on them is by no means new, octamethylpyrophosphoramide was early found to be much more promising than any systemic insecticide that had ever been tested.

Early development of octamethylpyrophosphoramide and its establishment as a commercial insecticide have been largely due to the work of Ripper and his associates (1949). Translocation studies based on results obtained with radioactive octamethylpyrophosphoramide containing P_{32} are described by David (1950), and many other investigators have extensive work in progress or reports in press.

The toxicology of this compound has been reported by Ripper (l.c.) and a comprehensive study of the toxicity and pharmacological action of octamethylpyrophosphoramide has recently been reported by DuBois, *et al.*, 1950.

In the studies reported here certain problems related to the use of octamethylpyrophosphoramide have been investigated in the laboratory and greenhouse, using the two-spotted spider mite, *Tetranychus bimaculatus* Harvey as the test species.

Kill of this mite is considered to be a criterion of absorption and translocation of octamethylpyrophosphoramide in bean plants.

The chemical used was a sample of distilled octamethylpyrophosphoramide with a high degree of purity. It is a colorless liquid, with specific gravity of approximately 1.12.

UPTAKE BY BEANS.—The amount of uptake of aqueous solutions of octamethylpyrophosphoramide by cut bean plants has been determined and correlated with kill of two-spotted spider mite.

PROCEDURE.—Young bean plants of uniform size were cut and held in tap water 24 hours for conditioning. They were held for 3 days in flasks containing weighed quantities of solutions of the chemical. The amounts of solution taken up by the plants were determined at the end of this period by difference in weight of the solutions. Mites were then transferred, counted and exposed for 5 days on the plants held in tap water. Survival was then recorded and the plants were weighed. The average number of mites used per plant was 87. Tests were run in triplicate at 3 concentrations.

During test the infested plants were held on greenhouse benches with the normal vicissitudes of greenhouse exposure. The night temperature was 60–62° F. Day temperatures and light characteristics were not recorded although marked fluctuations occurred.

DISCUSSION.—The rate of uptake of the solutions and the activity and feeding of the mites vary with light, temperature, humidity, air movement and other environmental factors. Therefore, it is necessary to conduct tests under strictly uniform conditions, or to carry out a large series of comparisons concurrently as was done here.

The weight of chemical taken up by the plants has been assumed to be in direct proportion to the weight of solution uptake. The possibility of differential absorption is recognized, but with water solutions in the range of 5 to 10 ppm. of

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Paid Paper.

Table 1.—Octamethylpyrophosphoramide uptake in cut bean plants.

Microgram Uptake per Gram of Plant	Corrected Per Cent Kill
7.2	38
7.8	42
8.2	49
9.7	52
12.3	70
12.4	77
14.0	76
15.0	87
16.0	90
18.0	90
20.0	98
22.5	99
24.0	94

the chemical, that situation seems remote and would be difficult to demonstrate conclusively.

On the basis indicated, the weight of chemical taken up by the plants was found to vary from extremes of 7.2 to 24.0 micrograms per 1 gram of plant green weight. The mean plant weight was 2.67 grams with extremes of 1.68 and 3.04 grams.

In preliminary tests it was observed that excessive concentration and uptake of the chemical killed the entire mite population in about 24 hours, but at the dosages considered here, 5 days exposure was required for reliable results.

When the dosage mortality curve is evaluated by a simplified method (Litchfield Wilcoxen, 1949), $(Chi)^2$ contribution of the line is found to be 21.62. With 11 d.f., this is approximately equal to the value when $p = .05$. The data are, therefore, not significantly heterogenous and the line is a reasonably good fit.

Interpolating from the data plotted in figure 1, 20 micrograms of chemical per gram of plant gave 95 per cent kill of mites under the conditions of test.

This amount is less than that found lethal to aphids by David & Kilby (1949), 60 to 100 micrograms per gram of plant, and we also have found several species of aphids to be more susceptible to this chemical than spider mites. However, the methods of test differ and the results are hardly comparable.

PLANT FOLIAGE TREATMENT.—The amount of octamethylpyrophosphoramide deposited when the leaves of bean plants were dipped in aqueous solutions has been correlated with spider mite kill, for comparison with applications of this chemical by other methods.

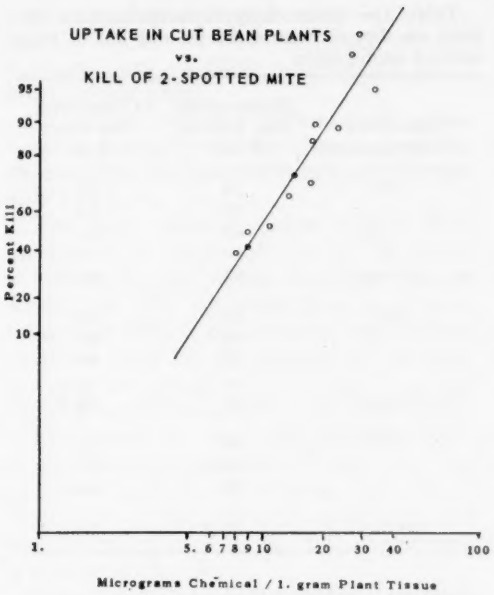

FIG. 1—Octamethylpyrophosphoramide.

PROCEDURE.—The 2 primary leaves of young cut bean plants were carefully dipped in various solutions of octamethylpyrophosphoramide and the weight of solution taken on by each plant was noted. The plants were then held for 3 days in tap water, after which mites were transferred and exposed for 5 days. Three plants were used at each concentration.

A neutral surface active agent of the alkyl aryl sodium sulfonate type was added to the solutions in a quantity just sufficient to allow spreading of the film.

DISCUSSION.—The data, table 2, immediately indicated that there was poor correlation between weight of chemical deposit and plant weight. Total plant weight in this case was apparently not closely correlated with total leaf surface on which the chemical was deposited. However, as demonstrated in figure 2, there is good agreement between concentration of the chemical applied and mite kill. Total chemical deposit is obviously dependent on total leaf surface, but leaf surface was not measured in these tests.

When calculated on the basis of the

Table 2.—Octamethylpyrophosphoramide deposit on dipped bean cuttings and kill of two-spotted spider mite.

Per Cent Concentration	Micrograms per 1 Gram Plant	Corrected Per Cent Kill
.020	54	93
	39	82
	49	85
Average	47	86.6
.014	28	86
	26	81
	31	68
Average	28	78.3
.010	20	75
	24.5	76
	16	59
Average	20.2	70

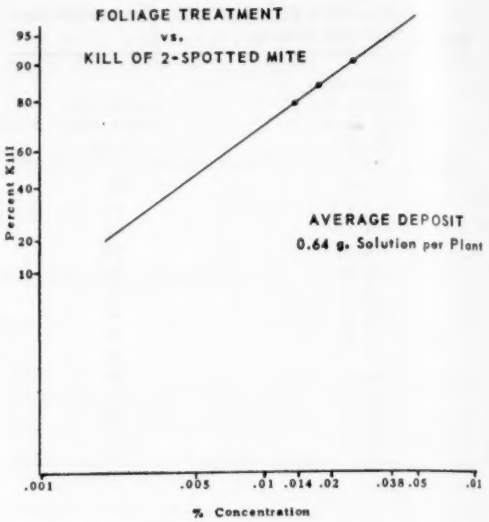

FIG. 2—Octamethylpyrophosphoramide.

average weight of deposit per plant, 0.64 gram of solution and the average weight of the plants, 3.0 grams, it is found that the LD 95 is 82 micrograms per 1 gram of plant weight.

In repeated tests under these conditions it was impossible to demonstrate a significantly higher kill of mites when plants with treated foliage were held longer than 3 days before infestation. At 1 and 2 days, the kill was reduced. It is believed that some absorption continued after 3 days and the chemical may have been translocated to new growth and other plant parts at about the same rate as it was absorbed. Volatilization of the chemical from the leaf surfaces also appears to be an important factor.

It is well known that under normal conditions of application of this chemical to greenhouse plants, the peak of kill of two-spotted spider mite may not be reached until 6 to 8 days after application. However, it is uncertain whether this is due to slow absorption of the chemical into the foliage or to inability of the mites to consume a lethal dose in a shorter time at the dilution used.

It was suspected that the type of surface agent and cosolvents used might alter the absorption of octamethylpyrophosphoramide when applied to the foliage, in the manner reported by Mitchell & Linder (1950) with 2,4-dichloro-5-iodophenoxyacetic acid. A study of this subject is now in progress and it is evident that various adjuvants alter the amount of octamethylpyrophosphoramide deposited on and absorbed by leaves.

A gross evaluation of lateral movement of octamethylpyrophosphoramide in bean plants was provided by a test in which only one of the primary leaves of young bean plants were dipped in a 0.1 per cent water solution of the chemical. Three days later the treated leaves were removed and mites were transferred to the untreated. This was replicated on six plants.

The mean deposit of chemical, applied to one leaf, was 105 micrograms per 1 gram of plant. The average kill of mites

Table 3. — Octamethylpyrophosphoramide watered on sand and soil.

Per Cent Concentration	Sand Per Cent Kill	Soil Per Cent Kill
0.1	96	99
0.05	90	85
0.025	52	50

Table 4. — Octamethylpyrophosphoramide watered on sand and soil.

Per Cent Concentration	Sand Per Cent Kill	Soil Per Cent Kill
0.1	100	97
0.05	100	87.5
0.025	100	74

on the untreated leaves was only 18 per cent, indicating that lateral translocation was much restricted. This is in agreement with studies using radio active octamethylpyrophosphoramide (David 1950).

TREATMENT OF GROWING MEDIUM.—Potted bean plants growing in sand and in soil were watered with octamethylpyrophosphoramide solutions to compare the efficiency of this laboratory procedure in mite control with those described above.

PROCEDURE I.—In the first series of tests young bean plants were planted in sand and soil in 4-inch pots of 500 cc. capacity. Both tops and roots were uniform. Tests were carried out in triplicate.

The plants, three per pot, were watered on the same day with 100 ml. of the indicated solution, table 3, and mites were immediately transferred and exposed for 7 days.

PROCEDURE II.—Bean plants were planted in pots of sand and soil 2 days previous to watering with 100 ml. of the chemical solutions. Three days after treatment (total 5 days) plants were cut, infested and held for 5 days for examination (Table 4).

DISCUSSION.—When the roots of the cut plants were examined the apparent discrepancy between sand and soil in tests I and II could be readily explained by the differences in the extent of the root systems. In test I, the root systems were similar in both media, but in test II the plants in sand had developed a much larger root system and could obviously absorb larger amounts of the available chemical.

PROCEDURE III.—Concurrently, potted beans in soil were watered with 50 ml. and 25 ml. of 0.1 per cent chemical solution and handled as in test II.

The respective mite kills were 92.5 and 65 per cent. When these points and that for 100 ml. are plotted (not shown) and compared with the curve for variations in dilution, there is close agreement on the amount of chemical required to give equivalent kill.

DISCUSSION. With bean plants established in soil for 2 days, and octamethylpyrophosphoramide solution present in the soil for the next 3 days, it was found that 0.16 gram of the chemical per 1000 cc. of soil was required for the plants to absorb a sufficient amount to then kill 95 per cent of transferred mites in 5 days exposure. On the basis of plant weight, this amounts to 6500 micrograms per 1 gram of cut plant.

It is expected that different soil types vary in capacity to fix the ions of the chemical so that part of it is held unavailable to plants.

The tests outlined below suggest that an excess of chemical was at all times available to the plants described above. Ability to take up quantities in a short time that were toxic to mites was limited in these tests by the extent of the root systems and activity of the plants rather than by the colloids in the growing media.

PERSISTENCE OF OCTAMETHYLPYROPHOSPHORAMIDE IN SOIL.—Since in the previous tests, it was obvious that only a small part of the chemical applied to soil was taken up in 3 days, the subject was investigated further.

PROCEDURE I.—Three bean plants were transplanted to soil in pots that had been watered with octamethylpyrophosphoramide solutions 36 days previously and had raised two groups of three bean plants each during this time. Three days later the plants were cut, infested with mites and held 5 days.

PROCEDURE II.—Bean plants that had grown in treated soil in pots for 16 days were cut, infested and held in tap water.

DISCUSSION.—The plants that were held for 16 days in treated soil took up such a large quantity of octamethylpyrophosphoramide that all mites were killed at the lowest dosage, 100 ml. of 0.025 per cent solution per 500 cc. of soil. As with the high dosages in other tests, the mites died within a few hours after they had settled down to feed.

Removal of two crops of bean plants from the same treated soil over a period of 36 days still left sufficient chemical available to the third group of plants. The mortality of two-spotted mites transferred to the third crop did not differ significantly from the earlier two groups.

EFFECT ON ROOTING OF CUTTINGS.—Octamethylpyrophosphoramide has sometimes appeared to stimulate the rooting of cotton and bean plant cuttings when they were held in dilute aqueous solutions.

To examine this supposition, bean plants having the primary leaves well expanded were cut and held for 9 days in flasks containing a series of octamethyl-

Table 5.—Effect of octamethylpyrophosphoramide aqueous solutions on rooting of bean cuttings.

Per Cent Concentration	Mean Rootlet Length MM.	Mean Rootlets per Plant
0.2	7	12
0.02	12.9	40
0.001	15	32
Control	17.3	29

pyrophosphoramide dilutions indicated in table 5.

Discussion.—When cut bean and cotton plants are protected from direct sun they root readily in tap water in 5 to 10 days. This procedure is useful in handling the two-spotted spider mite, since it facilitates counting without injury to the plant.

It was found that octamethylpyrophosphoramide does not affect rooting of beans at 0.001 or 0.02 per cent dilution. At 0.2 per cent concentration many rootlets died, blistered areas developed on the leaves, and rooting was inhibited.

However, in other tests where the soil of potted plants was saturated with 0.2 per cent solution of the chemical, no adverse effect on the roots or foliage was observed.

Summary.—Water solutions of octamethylpyrophosphoramide are readily taken up through the cut stems of plants, and the chemical becomes established in the foliage where it is toxic to spider mites feeding thereon. This was the most efficient method of application.

When the chemical is deposited in aqueous solution on the foliage, a relatively small part of it is absorbed into the cell sap and this occurs slowly. On the basis of total plant weight, about 4 times as much chemical was required on the leaves to give an effect comparable to that when the solutions was taken up through the cut stem.

Although octamethylpyrophosphoramide is readily translocated upward, the amount moving laterally is much restricted, and would be negligible under practical conditions of mite control.

The rapidity of kill of two-spotted spider mites is dependent on the rate at which the chemical is absorbed and transferred to the point at which the mites are feeding, and the extent to which the mites actually feed. Death of mites that have consumed a lethal dose occurs within a few hours.

For bean plants in treated soil the ratio of octamethylpyrophosphoramide in the plant tissue to plant weight increases markedly over at least a two-week period.

Absorption of sufficient octamethylpyrophosphoramide from treated soil in pots to cause high mortality of two-spotted spider mite on two crops of beans did not sufficiently alter the concentration of the chemical in the soil to reduce the kill of mites on the third bean crop.

Dilute aqueous solutions of octamethylpyrophosphoramide did not stimulate the rooting of bean cuttings. At 0.2 per cent concentration the chemical hindered rooting and injured the foliage. When soil in which beans were growing was saturated with the chemical at 0.2 per cent concentration there was no deleterious effect.

The relative efficiency of octamethylpyrophosphoramide in the soil tests described is not indicative of effects under field conditions, and this subject requires more thorough study.

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Two-Spotted Spider Mite Resistant to Aerosols

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Hexaethyl tetraphosphate was the first organic phosphate to be used in aerosols for control on greenhouse crops of the spider mite known as the two-spotted spider mite, *Tetranychus bimaculatus* Harvey. After the initial use of this material in rose houses in 1947 there was a marked increase in vigor and production of flowers, and the consequent elimination of, or great reduction in, the numbers of the spider mites (Smith *et al.* 1947, 1948). In 1948 when parathion became available in aerosols the same high degree of control of spider mites was obtained with this insecticide in most commercial greenhouses and with less frequent applications than were required with hexaethyl tetraphosphate (Blauvelt & Hoffman 1948, Smith *et al.* 1948). However, a rose grower in Cromwell, Conn.,[1] and another in Cranbury, N. J., called our attention to the poor results obtained with parathion when they first used it in August and October 1948.

These findings led to investigations that showed there were two strains of this mite with respect to its resistance to parathion. In this paper are presented the results of investigations, including studies on the differences in the strains, their relative susceptibility to insecticide aerosols, and the effect on them of host plants.

In February 1949 a laboratory-prepared aerosol containing parathion was applied in the Cranbury, N. J., greenhouse establishment and also in two others in Pennsylvania, where failures with parathion had been more recently reported. This aerosol had given good control of mites in numerous tests at Beltsville, Md., and in two commercial greenhouses nearby. However, although the tests in the commercial greenhouses in New Jersey and Pennsylvania were made under favorable conditions, a low kill of mites was obtained.

DISTRIBUTION OF RESISTANT MITES.—After the failure of the February tests, mites from the New Jersey and Pennsylvania infestations and others from 63 collections on rose and other hosts in 33 greenhouse ranges in Pennsylvania and Maryland were then compared with a laboratory culture of mites reared on rose or bean at Beltsville. This stock of mites had been a source of supply for three years. Mites from each collection in the three States were transferred to bean or rose plants in the same greenhouse with Beltsville mites and exposed to applications of an aerosol containing parathion, hexaethyl tetraphosphate, or tetraethyl pyrophosphate.

The adults and larvae of mites from the greenhouse range at Cranbury, N. J., and those from the range at Bloomsburg and at North Wales, Pa., survived the treatments with parathion aerosols that killed practically all the adults and larvae of mites from the other 30 ranges.

In further tests with parathion 12 collections of mites from localized infestations on roses in the Cranbury range, 8 collections from different houses in the Bloomsburg range, and four collections from two houses in the North Wales range, when tested separately, showed similar resistance to parathion. These results indicated that mixed colonies of resistant and nonresistant mites, often represented by single plant infestations, were not present in these ranges at the time of collection.

A study was made of the possibility that the three infestations of resistant mites, separated from one another by 50 to 100 miles, had a common origin by exchange of infested roses or other stock. Although the firm at Bloomsburg propagated roses for sale each year, the growers at North Wales and at Cranbury had procured no stock from that source in recent years.

These results indicated that in the area surveyed in February 1949 resistant mites were restricted to the three ranges. In June, however, for the first time resistant mites were encountered in ranges where only nonresistant mites had been previously collected, but they were definitely traced to introductions on rose plants recently purchased from the Bloomsburg range. Thus, although resist-

[1] The resistant mites at Cromwell, Conn., are being investigated by Philip Garman, Connecticut Agricultural Experiment Station.

ant mites were not widely distributed in greenhouses in the area surveyed early in 1949, their distribution was greatly extended in the late spring and summer on infested plants. By 1950 resistant mites were present in a large percentage of rose houses in the eastern states.

For use in further tests the Cranbury colony of mites was established from an infestation found on a single rose plant of the variety Yellow Gloria at Cranbury. These mites were transferred to bean and rose without treatment and have been maintained on them since February 4, 1949. Resistant mites from a Better Times rose plant in the Bloomsburg greenhouse have been similarly maintained on bean and rose without exposure to any treatment. Some practical results obtained in tests with resistant mites from these two colonies have been recorded (Smith & Fulton 1949, 1950).

RESISTANCE OF MITES TO VARIOUS CHEMICALS.—In tests to compare the relative toxicity of various chemicals to mites, infested leaves from the source colonies were pinned to cotyledon leaves on young bean plants, which were placed under lights to hasten wilting and transfer of mites. After eight to sixteen hours the vigorous mites were established on the plants, the source leaves were removed, and the plants were used in tests with nine organic phosphates and three other unrelated chemicals in aerosols at exposures of two hours or overnight.

Each of the materials killed a higher percentage of the Beltsville than of the other mites, as shown in table 1. Therefore it is evident that, compared with the Beltsville mites, the Bloomsburg and Cranbury strains were not only resistant to parathion but to all materials tested.

In addition to the above tests the systemic insecticide octamethyl pyrophosphoramide was applied in aerosols, in water as foliage sprays, or as soil applications against the two strains of mites. It was toxic to both strains but killed the nonresistant mites one or two days earlier than the resistant ones (Smith *et al.* 1950).

The results of the combined tests indicated that tetraethyl dithiopyrophosphate, p-chlorophenyl *p*-chlorobenzene sulfonate, and octamethyl pyrophosphoramide were the most promising materials for controlling the resistant mites. All have been used in practical commercial greenhouse tests. Tetraethyl dithiopyrophosphate has been widely used by florists during 1950 but the wider use of the other chemicals was restricted because they were not available in adequate quantities. Tests were made in May and June 1949 to compare the effect on resistant mites of two organic phosphate aerosols when applications are repeated as practiced in commercial greenhouses. Mites from the Cranbury culture reared on bean or rose since February 1949 were transferred to clean bean or rose, as were also the mites from the Beltsville colony. One week after transfer, when the mites had become established and were present in all stages, the plants were subjected at three-day intervals to four applications of hexaethyl tetraphosphate or of tetraethyl dithiopyrophosphate in 5-per cent aerosols at 1 pound per 50,000 cu. ft. Mites were counted on 20 disks, 14 mm. in diameter, cut from leaves of each host. The results are shown in table 2. It is evident that practical elimination of the susceptible Beltsville mites can be obtained by treatment with either aerosol. Against resistant mites the hexaethyl tetraphosphate was inferior to tetraethyl dithiopyrophosphate.

Mites reared on bean or rose for three or four months were equally resistant to both materials. The tests also indicated the need for at least five applications of tetraethyl dithiopyrophosphate to reduce the population to a low level.

EFFECT OF HOST PLANT ON RESISTANCE.—Garman (1950) reported that resistant mites on roses from the Cromwell colony lost practically all of their resistance when reared on bean for approximately four months. Garman found that mites reared on bean assimilated large quantities of molybdenum and showed little resistance to parathion. Neiswander *et al.* (1950) reported that host plants influenced the rate of development of two-spotted spider mites and their susceptibility to acaricides.

In the present studies resistant mites collected on February 4, 1949, from roses at Cranbury and Bloomsburg were reared in separate colonies on bean or rose for 10 months. During this period the stocks of mites on these hosts were not exposed to any acaricide, and none of the mites taken from the colonies for experimentation and surviving any chemi-

cal treatment were returned to the parent colonies. The resistance of these mites to parathion and to other chemicals in methyl chloride aerosols did not decline in 18 tests conducted from February through December. The results with mites from the Cranbury colony maintained on bean are recorded in table 3. It is evident that their resistance was not lowered, whereas the Beltsville colony lacked resistance even though maintained on bean. It would appear that the mites in the original collections from single-plant colonies at Bloomsburg and Cranbury were homozygous for resistance, and their progeny have not lost this resistance through an estimated 20 to 25 generations.

The colonies investigated by Garman and by Neiswander *et al.* may have been heterozygous for the character of resistance which was lost in succeeding generations.

HOST PLANTS OF RESISTANT MITES.—In the three greenhouse ranges in which parathion-resistant mites were recognized early in 1949 they were on roses and on at least 9 weed hosts in the beds (Smith & Fulton 1949). Resistant mites from the Cranbury or Bloomsburg colonies were established by transfer or natural migration on 11 other crops in the greenhouse, including ageratrum, carnation, China aster, chrysanthemum, cucumber, bean, snapdragon, and tomato. Mites from these hosts were compared with the original colonies on bean or rose in tests with parathion aerosols and in no case was there evidence of loss in resistance due to the effect of the host.

Investigations have been made of the possibility that resistant mites would become established on vegetation outside greenhouses, especially near piles of trimmings and discarded material from infested plants that accumulate at the service entrances. In September 1949 a careful survey of 45 weed hosts adjacent to the Bloomsburg greenhouses revealed seven species of plants infested with two-spotted spider mites. None of the collected mites were resistant to parathion aerosols, although resistant colonies were present inside the greenhouse on roses within 10 feet of the outdoor colonies.

MORPHOLOGICAL STUDIES OF MITE STRAINS.—In view of the difference in reaction of mites from various sources used in these tests the question was raised whether they were all of the same species. E. W. Baker, of the Bureau of Entomology and Plant Quarantine, and A.

Table 1.—Comparison of toxicity of several organic phosphates and other chemicals in methyl chloride aerosols to two strains of two-spotted spider mites.

Ingredient in Aerosol	Grams Active Ingredient per 1000 Cu. Ft.	Number of Tests	Beltsville Mites				Resistant Mites			
			Adults		Larvae		Adults		Larvae	
			Number Examined	Per Cent Killed	Number Examined	Per Cent Killed	Number Examined	Per Cent Killed	Number Examined	Per Cent Killed
Parathion 10%, acetone 10%	1	16	2,839	99.9	1,646	99.1	3,867	5	1,763	4
Diethyl *p*-nitrophenyl phosphate (oxygen analog of parathion 10%, acetone 10%	1	2	140	100	156	100	193	6	178	4
0,0-Dimethyl 0-*p*-nitrophenyl thiophosphate (methyl homolog of parathion) 10%, acetone 10%	1	3	242	39	547	52	726	0	375	0
E605[1] 10%, acetone 10%	1	2	283	100	97	100	349	1	116	4
0-Ethyl 0,0-bis(*p*-nitrophenyl)-thiophosphate 5%, methylene chloride 10%	1	2	218	19	78	41	332	8	271	2
Hexaethyl tetraphosphate[2] 5%	.5	13	2,027	99.7	994	100	3,393	39	1,165	66
Tetraethyl pyrophosphate[3] 5%	.25	3	770	97.4	419	100	765	12	307	25
Tetraisopropyl pyrophosphate 5%	.5	2	314	98	156	99	260	38	105	46
Tetraethyl dithiopyrophosphate 5%	.5	20	2,524	100	1,431	100	3,271	59	2,566	91
1,1-Bis(*p*-chlorophenyl)-ethanol 5%, acetone 5%	.5	2	197	100	128	100	119	0	131	0
2-(*p-tert*-butylphenoxy)-1-methylethyl 2-chloroethyl sulfite 5%	1	2	156	97	238	100	129	22	65	100
p-Chlorophenyl *p*-chlorobenzene sulfonate 5%	1	1	127	100	137	100	137	2	67	4
	2	1	165	98	101	100	168	34	145	72
	.5	2	238	100	296	100	286	9	350	25
	1	2	257	100	316	100	559	99	432	99.7

[1] Sample of German origin.
[2] 5 per cent of hexaethyl tetraphosphate containing 12.3 per cent of tetraethyl pyrophosphate.
[3] 5 per cent of 38.5 per cent tetraethyl pyrophosphate.

Table 2.—Resistance of two strains of two-spotted spider mites reared on bean or rose to two organic phosphates in methyl chloride aerosols applied four times at 3-day intervals.

Organic Phosphate	Host	Resistant Mites		Beltsville Mites	
		Dead	Living	Dead	Living
Hexaethyl tetraphosphate 5 per cent	Bean	632	736	599	4
	Rose	539	667	—	—
Tetraethyl dithiopyrophosphate 5 per cent	Bean	688	112	493	1
	Rose	553	70	—	—

Earl Pritchard, of the University of California, have made critical comparisons of nonresistant mites from the Beltsville culture and other sources with resistant mites from Bloomsburg, North Wales, and Cranbury.

The adult females of all resistant mites used in the present investigations were green or slightly orange with brown spots and were typical two-spotted spider mites, *Tetranychus bimaculatus* Harvey. A subcolony of resistant mites, at present designated as a carmine form of *T. bimaculatus*, was recently segregated from the Cranbury colony but progeny tend to revert to the green form with brown spots.

The nonresistant mite from the Beltsville colony is at present designated as a red form of *Tetranychus bimaculatus*. Collections have been made from commercial greenhouses of nonresistant mites, which in life resembled the typical brown-spotted green form of *T. bimaculatus*. The present studies have not disclosed morphological differences between the nonresistant and the resistant mites that are now designated as *T. bimaculatus*.

Discussion.—Observations have been made on pest-control programs in various greenhouse ranges since early in 1947, when hexaethyl tetraphosphate was first used in aerosols or sprays for the control of mites. In 1947 aerosol treatments with this material were made by the writers in a large number of greenhouse ranges, including those at Cromwell, Conn.; Cranbury, N. J.; and Bloomsburg, Pa., which are now known to contain resistant mites. However, those treatments did not give the high degree of mite control

Table 3.—Resistance of two strains of two-spotted spider mites reared on bean to 10-per cent parathion in methyl chloride aerosol applied at 1 gram per 1,000 cu. ft. Exposures for two hours or overnight

Date of Test	Beltsville Mites				Cranbury Mites			
	Adults		Larvae		Adults		Larvae	
	Number Examined	Per Cent Killed	Number Examined	Per Cent Killed	Number Examined	Per Cent Killed	Number Examined	Per Cent Killed
Feb. 11	254	100	—	—	496	1	—	—
17	113	100	—	—	83	7	85	100
27	116	100	70	100	448	5	221	76
Mar. 3	96	100	113	100	216	1	100	40
15	376	100	51	100	261	2	39	3
28	138	100	149	100	174	4	128	0
Apr. 28	188	100	22	100	214	11	15	0
May 5	277	100	19	100	284	5	121	2
10	156	100	19	100	152	5	116	12
25	143	100	163	100	162	2	21	0
June 13	122	99	152	100	135	1	40	0
23	176	100	138	100	204	4	121	25
July 19	155	100	151	100	181	28	162	0
Aug. 4	198	100	90	100	226	5	260	3
Sept. 12	178	99	219	100	108	1	148	3
Oct. 6	116	99	113	100	153	3	189	2
Nov. 22	221	100	108	100	266	5	143	0
Dec. 3	218	100	195	100	236	12	238	1

obtained in other ranges. Although the greenhouse operators, by following the same program of repeated applications and proper dosages, kept the mites at low levels of population, they did not attain the point of virtual eradication that other growers obtained in their greenhouses. These poor results were attributed to uneven distribution caused by convection currents near heating pipes or in leaky houses. However, when these growers changed to the use of parathion aerosols in 1948, it was immediately evident that the resistant mites did not succumb. The studies indicate that these resistant mites existed when parathion and hexaethyl tetraphosphate were first used. Prior to the use of phosphate insecticides spider mites had been controlled in these ranges with azobenzene.

Because roses are grown for several years before individual plants are discarded and because a given rose house may contain one or more beds of roses for 30 to 50 years or longer, this crop represents a more nearly permanent host for mites than most other greenhouse crops. It is reasonable to assume that resistant mites would be more likely to appear and to persist on this crop than on others that are discarded after a few months.

SUMMARY.—Hexaethyl tetraphosphate, first used in aerosols in 1947, was highly effective against the spider mite now known as the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, on greenhouse crops and its use resulted in increased production and quality of flowers.

In 1948 when parathion was first used commercially the material was equally effective except in three ranges where poor kills of mites were obtained.

Investigations early in 1949 showed that of 33 greenhouses surveyed resistant mites were found within three of them but not on vegetation outside of these greenhouses. Later in the year resistant colonies were encountered in additional ranges and were traced to introduction on plants purchased from one of the original 3 ranges. Resistant mites were widespread by 1950.

In comparative tests using two strains of mites, those found to be resistant to parathion were also resistant to some extent to eight other organic phosphates and to three unrelated compounds—1,1-bis(*p*-chlorophenyl) ethanol, 2-(*p*-*tert*-butylphenoxy)-1-methylethyl 2-chloroethyl sulfite, and *p*-chlorophenyl *p*-chlorobenzene sulfonate. Moreover, their resistance to parathion was not lost when reared without exposure to insecticides on bean or rose for 10 months or on 11 other crops and on weeds for shorter periods.

Resistant mites were most effectively controlled with tetraethyl dithiopyrophosphate, octamethyl pyrophosphoramide, and *p*-chlorophenyl *p*-chlorobenzene sulfonate.

No morphological differences have been found between resistant and nonresistant spider mites that are now designated as *Tetranychus bimaculatus* Harvey.

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Several Injurious Ornamental and Shade Tree Insects and Their Control[1]

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For a long time, insect damage to ornamental shade trees and shrubs in Rhode Island has been a serious problem, not only for the commercial nurseryman, but for the home owner and others who endeavor to cultivate such plants. In many instances the available information on effective control measures, particularly the timing of insecticide applications, has proven inadequate. While some progress has been made in the chemical control of such insects there remains a very definite place for additional studies. This report is a continuation of investigations begun in 1949 (Kerr 1950) and concerns field experiments undertaken in 1950 involving the locust leaf miner, *Chelepus dorsalis* Thunb., the fall webworm, *Hyphantria cunea* (Drury), the orange-striped oakworm, *Anisota senatoria* (A. & S.), the pine needle scale, *Phenacaspis pinifoliae* (Fitch), Fletcher scale, *Lecanium fletcheri* Ckll., and three additional species of scale insects having no accepted common name, *Pulvinaria floccifera* (Westw.), *Lecanium coryli* (L.) and *Lecanium querciflex* Fitch.

MATERIALS.—The details relative to the materials, concentrations and combinations used in each experiment are given in tables 1 to 9 and will not be elaborated here other than to state the type of formulation used and the fact that all were available commercially. All of the chlorinated hydrocarbon insecticides were wettable powders and included 50 per cent DDT, 40 per cent chlordane, 25 per cent lindane, 25 per cent aldrin and 25 per cent dieldrin. Nicotine sulphate was employed as the conventional 40 per cent solution. Lime-sulphur, used in liquid form, was guaranteed to have a density of not less than 31° and not more than 33° Baumé at 60° F. The only arsenical was acid lead arsenate, and it was used in combination with a sticking agent composed of protein materials and a clay. An additional wetting agent[2] was used with the chlorinated hydrocarbon insecticides and with nicotine sulfate as indicated in several of the experiments. One of the petroleum oils used was a "superior" type dormant tree spray oil, the specifications for which were outlined by Chapman & Pearce (1949). It was emulsified by the addition and blending of 50 cc. of a polyoxyethylene sorbitol hexoleate[3] to each gallon of oil previous to use in the field against *Lecanium querciflex*. A second type of proprietary self-emulsifying petroleum product, included in an experiment involving the pine needle scale, was reputed to contain 86 per cent petroleum distillate, 11 per cent naphthenic soaps and 3 per cent inert ingredients. Except where indicated, the materials in all experiments were applied with a power sprayer.

LOCUST LEAF MINER.—In Rhode Island, the black locust is attacked severely each year by one of its most troublesome pests, the locust leaf miner. In 1950, overwintered adults of the insect were observed first on May 26 when the new vegetative growth of locust was 1 to 2 inches long. Egg deposition began on June 6, the greatest number being deposited during the period of June 11 to 17. Hatching of the eggs was observed first on June 27. Although overwintered adults could be found until the first week in August, few eggs were deposited after early July. In 1950 there was one generation of the insect.

Experiments were conducted on trees averaging 9 feet in height and heavily infested with beetles. Each insecticide was applied to 12 trees on June 2 at the rates indicated in table 1. On June 9, eight of the trees in each treatment received a second application of spray, while on June 18 a third spray was applied to 4 trees that had received both the first and second application. Data on control were obtained August 4 and 5 when an average of 700 random leaflets on each tree in all treatments were examined for larval feeding injury. The results are presented in table 1.

DDT was more effective than either chlordane or lead arsenate in preventing

[1] Contribution No. 770 from the Rhode Island Agricultural Experiment Station, Kingston, R. I.
[2] *Triton B-1956*, a phthalic glyceryl alkyd resin.
[3] *Atlas G-1086*.

Table 1.—Control of the locust leaf miner with various insecticides. North Kingstown, R. I., June-August, 1950.

Material[1]	Amount in 100 Gal. Water	Applications	Leaflets per 100 Injured by Larvae	Control
	Lb.	No.	No.	%
DDT 50% W	2	3	1.1	92.3
		2	5.2	65.2
		1	6.7	54.8
	1	3	3.4	77.0
		2	5.0	66.4
		1	8.9	40.5
Chlordane 40% W	2.5	3	2.6	82.9
		2	5.8	61.3
		1	8.0	46.6
	1.25	3	4.2	71.9
		2	11.5	22.6
		1	14.6	2.1
Lead arsenate +sticker	4 1	3	1.6	89.1
		2	7.2	51.7
		1	7.3	50.9
Check			14.9	

[1] *Triton B-1956* at the rate of 4 ounces in 100 gallons of water was included with each insecticide, except lead arsenate.

egg deposition and subsequent larval attack. Three applications of 2 pounds of wettable 50 per cent DDT was the most effective treatment. Although the standard recommendation (Becker 1938) for control of the insect has been a single application of lead arsenate, it was found that at least three applications of the material were necessary to produce 89.1 per cent undamaged leaflets. Two and three applications, each containing 4 pounds of lead arsenate plus one pound of sticker, resulted in severe injury to the locust foliage. Both chlordane and DDT applied three times at the higher concentration resulted in a perceptible yellowing of the older leaflets.

FALL WEBWORM.—During the past 5 years this insect has been injurious to many trees and shrubs. Host plants included in the experiment were cherry, apple, pear, dogwood, elm and *Ilex* on which one or more nests of immature larvae of the insect were present. Each of the treatments and the unsprayed check consisted of 5 plants and was infested with approximately 1200 larvae. On August 15, the materials were applied to the nests and surrounding foliage at the rates indicated in table 2. Although the data on control were obtained at the expiration of 3 days by counting the number of dead and live larvae, it was observed that DDT acted much faster than did lead arsenate, the standard material (Herrick, 1935). Practically all

Table 2.—Control of the fall webworm and orange-striped oakworm with various insecticides. Wakefield, R. I. August and September, 1950.

Material[1]	Amount in 100 Gal. Water	Fall Webworm Control in 3 Days	Orange-Striped Oakworm Control in 3 Days
	Lb.	%	%
Lead arsenate plus sticker	4 and 1	97.1	98.5
DDT 50% W	2	99.9	100.0
	1	99.8	98.8

[1] *Triton B-1956* at the rate of 4 ounces in 100 gallons of water was included with DDT.

of the larvae on plants sprayed with the former material were dead within 24 hours, while those sprayed with the latter insecticide succumbed at a slower rate. However, both DDT and lead arsenate were equally effective in controlling the insect.

ORANGE-STRIPED OAKWORM.—During late August and early September of the current season, oaks used for ornamental purposes, and others in several parts of the forested areas of Rhode Island were defoliated seriously by the larvae of this insect. Employing hand-operated equipment, several species of small oak infested with one or more groups of immature larvae were sprayed on September 6 with the materials listed in table 2. Five trees containing a total of approximately 400 larvae were included in each of the treatments and the unsprayed check. The results obtained were much the same as those stated above for the fall webworm. Both the standard material, lead arsenate, (Herrick 1935) and DDT were 97 per cent or more effective. Again, DDT acted much faster than did lead arsenate in killing the larvae.

PINE NEEDLE SCALE.—This insect is oftentimes found in destructive numbers in isolated ornamental plantings of pine. In Rhode Island there were two distinct broods of the insect in 1950. Crawlers hatching from the overwintered eggs appeared first on June 5. One week later all of the eggs had hatched, the crawlers settling on needles produced in 1949. The first brood matured in mid-July and by August 1 eggs of the second generation had been laid. Crawlers of the second generation appeared on the 1949 foliage and that of the current season on August 10, but all of the eggs did not hatch until August 28. The overwintering eggs were

observed again during late September.

Red pines, 20 to 25 feet in height, were used in three experiments involving the overwintered eggs and nymphs of the first and second generations. In some experiments one-half of a tree was used, in others, one-quarter of a tree provided sufficient area. In all cases, the trees were divided perpendicularly.

In the first experiment the materials listed in table 3 were applied on May 7 and 8 when the trees were in a dormant condition and the insect in the egg stage. Data on control were obtained on June 13 and 14 by counting the number of live immature scale on 100 needles from twigs selected at random in each treatment. Results given in table 3 show that petroleum oil, the standard insecticide (Pettit, 1925), was 100 per cent effective as an ovicide in controlling the insect. The control of 67.3 per cent and 49.2 per cent, respectively, for DDT and chlordane is believed due to residual action of the materials against the newly hatched crawlers, for the eggs hatched normally under the old scale in these treatments. Dieldrin, aldrin, and lindane were ineffective as ovicides and as residual materials against the crawlers.

The second experiment was initiated on June 15 when the materials listed in table 4 were applied to nymphs that had settled on the needles. Data on control were obtained during the period July 8 to 14 by counting the number of live male and female scales on 100 needles from random twigs in each treatment. Results presented in table 4 show both nicotine sulfate, the standard insecticide (Turner 1930) and DDT were 85.8 and 81.2 per cent effective, respectively, in controlling nymphs recently settled on the needles. Chlordane and lindane were both ineffective. When the data were obtained the scale population in both of the chlordane treatments and the higher concentration of the lindane treatment was greater than the check treatment. This may be attributed to the adverse influence of these two materials on various coccinellid predators that were active in the experimental area, particularly in the check and nicotine sulfate treatments, when the scale were immature. Their feeding activities tended to reduce the scale population in these treatments more than in the chlorinated hydrocarbon insecticide treatments.

The third experiment was undertaken on August 14 when the first application of materials shown in table 5 was made to the trees for control of second-generation crawlers. On August 30, when all of the second-generation eggs had hatched, a second application of these materials was made to one-half of each area receiving the first application. Data presented in table 5 were obtained during the period of September 23 to 29 by counting the number of mature male and female scale on 100 needles from random twigs in each treatment. The needles selected were those produced in 1950. DDT was superior to nicotine sulfate for control of the insect. There was no difference between 2 and 4 pounds of wettable 50 per cent DDT applied once or twice for control of the female scale. In all instances a control of 99 per cent or more was obtained. One quart of 40 per cent nicotine

Table 3.—Control of the pine needle scale with various insecticides applied as dormant sprays. Wakefield, R. I. May–June 1950.

Material[1]	Amount in 100 Gal. Water	Nymphs per Cm. of Needle	Control
		No.	%
Petroleum oil	5 gal.	0.00	100.0
DDT 50% W	2 lb.	.78	67.3
Chlordane 40% W	2.5 lb.	1.21	49.2
Dieldrin 25% W	4 lb.	1.99	16.7
Aldrin 25% W	4 lb.	2.16	9.7
Lindane 25% W	1 lb.	2.11	11.3
Check		2.39	

[1] *Triton B-1956* at the rate of 4 ounces in 100 gallons of water was included with each insecticide, except petroleum oil.

Table 4.—Control of first-generation nymphs of the pine needle scale. Wakefield, R. I. June, 1950.

Material[1]	Amount in 100 Gal. Water	Insects per Cm. of Needle	Control
		No.	%
Nicotine sulfate 40%	1 pt.	0.17	85.8
DDT 50% W	1 lb.	0.52	56.2
	2 lb.	0.22	81.2
Chlordane 40% W	1.25 lb.	1.52	26.9[2]
	2.50 lb.	1.32	10.2[2]
Lindane 25% W	1.0 lb.	1.27	6.0[2]
	0.5 lb.	0.82	31.2
Check		1.19	

[1] *Triton B-1956* at the rate of 4 ounces in 100 gallons of water was included with each insecticide.
[2] Denotes increase rather than reduction.

Table 5.—Control of second-generation nymphs of the pine needle scale. Wakefield R. I. August–September, 1950.

Material[1]	Amount in 100 Gal. Water	Applications	Insects per Needle[2]		Control of Female
			Male	Female	
		No.	*No.*	*No.*	*%*
DDT 50% W	2 lb.	1	2.19	.10	99.5
	2 lb.	2	.33	.15	99.2
	4 lb.	1	.50	.00	100.0
	4 lb.	2	.77	.17	99.1
Nicotine sulfate 40%	1 qt.	1	.36	9.15	52.5
	1 qt.	2	.20	3.42	82.3
Check			.37	19.27	

[1] *Triton B-1956* at the rate of 4 ounces in 100 gallons of water was included with each insecticide.
[2] Data adjusted for variation in needle length.

sulfate was 52.5 per cent effective against the female scale when applied once and 82.3 per cent when applied twice. Although the number of male scale found was small, amounting to approximately 2 per cent of the total population in the check treatment, it was interesting to note that equal or larger numbers were found in all other treatments except where nicotine sulfate was applied twice. In addition, it was observed that while 83 to 100 per cent of those in the nicotine sulfate treatment and 63 per cent in the check treatment were still in the pupal stage, 98 to 100 per cent of the male scale in the DDT treatment had emerged from the pupal stage.

One explanation advanced to account for the difference in control obtained with DDT against the first and second generation of pine needle scale is that the material was applied 10 days after first crawlers of the first generation appeared and 4 days after those of the second generation were found. The evidence indicates that the material was more effective against the newly-hatched crawlers than those that had settled on the foliage.

PULVINARIA FLOCCIFERA (WESTW.) AND FLETCHER SCALE.—In a previous report by the writer (Kerr 1950) data were presented showing both nicotine sulfate and DDT effective for control of newly-hatched nymphs of an unknown species of *Pulvinaria* on yew. Since the advent of the publication it has been established that the species in question was *Pulvinaria floccifera* (Westw.). In Rhode Island *P. floccifera* and Fletcher scale often are found in association on yew, the former species being more abundant and injurious than the latter. In order to ascertain the feasibility of dormant applications for control of both insects, tests were conducted on a hedge of Hick's yew, *Taxus media hicksi*, infested with overwintered nymphs of both species of scale, and large enough to provide for three insecticide treatments and an unsprayed check. On April 28, each of the materials indicated in table 6 was applied to three replicated plots measuring 7 feet high, 3 feet deep and 3 feet wide. On July 7, data on control were obtained by counting the number of mature female scales on an average of 224 linear inches of twigs in each replicate of the treatments.

Table 6.—Control of female *Pulvinaria floccifera* and female *Lecanium fletcheri* with various insecticides as dormant applications. Kingston, R. I., April, 1950.

Material[1]	Amount in 100 Gal. Water	*Pulvinaria*		*Fletcher scale*	
		Per Inch of Twig	Per Cent Control	Per Inch of Twig	Per Cent Control
	Lb.	No.		No.	
DDT 50% W	2	0.004	99.7	0.474	28.7
Aldrin 25% W	4	0.964	27.6	0.630	5.2
Dieldrin 25% W	4	0.731	45.1	0.451	32.2
Check		1.332		0.665	

[1] *Triton B-1956* at the rate of 4 ounces in 100 gallons of water was included with each insecticide.

Table 7. Control of female *Lecanium coryli* on dogwood with various insecticides as dormant applications. Middletown, R. I. April to June, 1950.

Material	Amount in 100 Gal. Water	Adult Females per Inch of Twig	Per Cent Control
		No.	
Lime-sulphur[1]	10 gal.	0.64	68.8
Aldrin 25% W	4 lb.	1.28	37.3
Dieldrin 25% W	4 lb.	1.75	14.4
Chlordane 40% W	2.5 lb.	1.78	13.0
DDT 50% W	2 lb.	2.04	0.5
Check		2.05	

[1] Used at the rate of 10 gallons in 90 gallons of water.

Results given in table 6 show DDT was 99.7 per cent effective and both aldrin and dieldrin relatively ineffective as dormant treatments for control of *P. floccifera*. On the other hand, all three materials, particularly aldrin, were relatively ineffective for control of Fletcher scale during the dormant season.

LECANIUM CORYLI.—This insect was found first in 1949 infesting nursery stock in Middletown, Rhode Island. Subsequent scouting in 1950 revealed a severe infestation confined particularly to the city of Newport and the town of Middletown. Hosts on which it was abundant included dogwood, elm, horsechestnut, linden and maple. Other hosts less severely attacked were apple, beech, birch, boxelder, peach, rose and viburnum.

During 1950 the life history of the insect in Rhode Island was similar to that reported by Hanson & Webster (1938) in Washington, and Glendenning (1925) for British Columbia except for the time of appearance of the various stages. The nymphs overwintered on the twigs and underside of the smaller branches of the host plants. Macroscopically the sexes could not be distinguished until May 15 when several male pupae were found. Eggs were observed first under the female scale on June 8. Hatching of the eggs took place during late June and early July and on the 12th of the latter month all had hatched. The young crawlers settled on both the upper and lower surfaces of the leaves of their hosts. During late September and in October they migrated back to the woody growth, particularly to areas produced during the current season.

Table 8.—Control of first instar *Lecanium coryli* on dogwood with various insecticides. Middletown, R. I. July 1950.

MATERIAL[1]	AMOUNT IN 100 GAL. WATER	SCALES PER LEAF	PER CENT CONTROL
Nicotine sulfate 40%	3 pt.	6.7	93.3
	2 pt.	13.1	87.1
	1 pt.	30.0	70.3
DDT 50% W	2 lb.	35.9	64.5
	1 lb.	63.8	36.8
Lindane 25% W	1 lb.	62.1	38.5
	.5 lb.	64.7	35.9
Check		100.9	

[1] *Triton B-1956* at the rate of 4 ounces in 100 gallons of water was included with each insecticide.

Dogwood 10 to 12 feet tall, were used in two experiments involving overwintered nymphs and newly-hatched nymphs. In the first experiment, the materials listed in table 7 were applied as dormant sprays on April 17 and 18 using five replicated trees per treatment. Data on control were obtained on June 14 by counting the number of mature female scale on an average of 50 linear inches of twigs in each replicate of the treatments. The results presented in table 7 show that none of the materials were effective for controlling the overwintered nymphs. Liquid lime-sulphur reduced the scale population 68.8 per cent, but the remaining scale deposited sufficient eggs to reinfest the trees with a heavy population of nymphs. Aldrin, dieldrin and chlordane were relatively ineffective against the insect. DDT had no effect on the overwintered population.

The second experiment was undertaken on July 12 when the materials included in table 8 were applied to newly-hatched nymphs on the leaves using 4 replicated trees per treatment. During the period of July 26 to August 10, data on control were obtained by counting the number of live nymphs on 20 leaves from the trees in each treatment. One leaf of a basal pair on random terminal twigs was selected, for it was found that such leaves were infested most uniformly and presented the most difficult target for coverage by spray materials. Results given in table 8 show that nicotine sulfate was the most effective material for controlling the insect. It was observed that the degree of control was affected adversely by the sericeous nature of the pubescence on the underside of the leaves, particularly that along the veins. Many of the young scales crawled under the appressed hairs where

Table 9.—Control of female *Lecanium quercifex* on oak with various insecticides applied as dormant applications. Middletown, R. I. April-June, 1950.

MATERIAL	AMOUNT IN 100 GAL. WATER	ADULT FEMALES PER INCH OF TWIG	% CONTROL
Petroleum oil	2 gal.	0.11	94.7
Dieldrin 25% W	4 lb.	1.15	44.2
Aldrin 25% W	4 lb.	1.46	29.5
Check		2.07	

they were wetted incompletely or not at all by the spray materials. Leaves produced on the lateral twigs were less sericeous and as a result control of the nymphs was more complete, particularly in the nicotine sulfate treatment. It is interesting to note that DDT was more effective against newly-hatched nymphs than it was against overwintered nymphs. Lindane was relatively ineffective in controlling the insect.

LECANIUM QUERCIFEX.—A soft scale found in scattered locations throughout Rhode Island on several species of oak is *Lecanium quercifex* Fitch. The seasonal history of the insect was similar to that outlined for *L. coryli*, except that the egg stage was about one week later. Tests were conducted on nursery stock using pin oak, 7 to 12 feet high, heavily infested with overwintered nymphs. The materials listed in table 9 were applied as dormant sprays to 4 replicated trees in each treatment on April 19. On June 14, an average of 50 linear inches of twigs in each replicate of the treatments was examined for female scales. The results presented in table 9 show a "superior" type dormant petroleum oil was effective in controlling the insect and aldrin and dieldrin were ineffective.

SUMMARY.—During 1950 the comparative insecticidal effectiveness of petroleum oil, lime-sulphur, lead arsenate, nicotine sulfate and several chlorinated hydrocarbon materials, and the timing of such insecticide applications, was investigated in field tests involving eight insects attacking ornamental trees and shrubs.

DDT was more effective than either chlordane or lead arsenate for control of the locust leaf miner. Three applications, each containing 2 pounds of wettable 50 per cent DDT in 100 gallons of water, the first made one week after the first adults were observed and the second and third 7 and 9 days later, respectively, resulted in 92.3 per cent control of the larvae. Three applications of DDT at the above concentration resulted in a perceptible yellowing of the older leaflets, while two and three applications of 4 pounds of lead arsenate with one pound of sticker were severely injurious to the foliage.

Both wettable 50 per cent DDT and lead arsenate were equally effective in single applications for control of the fall webworm and the orange-striped oakworm. Two pounds of the former and 4 pounds of the latter with 1 pound of sticker in 100 gallons of water were 97 per cent or more effective against the larval stages. The insecticidal action of DDT was more rapid than that of lead arsenate.

A 5 per cent petroleum oil spray applied in early May was 100 per cent effective as an ovicide in controlling the pine needle scale. DDT, chlordane, aldrin, dieldrin, and lindane were ineffective as ovicides, but the first two materials mentioned did exhibit residual action against the first generation of crawlers. Single applications of one pint of 40 per cent nicotine sulphate and 2 pounds of wettable 50 per cent DDT in 100 gallons of water were 85.8 and 81.2 per cent effective, respectively, against first-generation nymphs that had settled on the needles. Chlordane and lindane were ineffective in controlling nymphs recently settled on the needles. One application of 2 pounds of wettable 50 per cent DDT was superior to two applications of 2 quarts of 40 per cent nicotine sulfate for control of second-generation female crawlers. Evidence is presented to show that both materials, particularly DDT, had little insecticidal effect on the male crawler of the second generation.

One application of 2 pounds of wettable 50 per cent DDT in 100 gallons of water applied as a dormant treatment in late April was 99.7 per cent effective for control of female *Pulvinaria floccifera* (Westw.) on yew, while both aldrin and dieldrin were relatively ineffective. All three materials were ineffective for control of female Fletcher scale on yew.

Lime-sulphur, aldrin, dieldrin and chlordane were ineffective when applied as dormant sprays for the control of overwintered female nymphs of *Lecanium coryli* (L.) on dogwood. One application of 3 pints of 40 per cent nicotine sulfate in 100 gallons of water was 93.3 per cent effective for controlling newly-hatched nymphs on the leaves of dogwood in July. DDT and lindane were relatively ineffective for this purpose.

A 2 per cent "superior" type dormant petroleum oil spray applied to pin oak in mid-April was 94.7 per cent effective for control of overwintered female nymphs of *Lecanium quercifex* Fitch, while aldrin and dieldrin were ineffective.

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Field Studies on the Bionomics and Control of the Broad Bean Weevil

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Prior to the first world war the growing of broad or fava beans, *Vicia faba* L. was of considerable local importance in certain areas of California, but with the introduction (*circa* 1888) (Campbell 1920) and steady increase in numbers of the broad bean weevil, *Bruchus rufimanus* Boh., there ensued the early abandonment of considerable acreage formerly devoted to this crop. The area around San Francisco Bay and south along the coast to San Luis Obispo annually produced as many as 200,000 bags of beans before it became impossible to grow an uninfested crop. Production during 1920 in this area dropped to 50,000 bags. San Mateo County alone produced annually well over 40,000 bags prior to the time that this insect became so abundant. In 1949 this county's production had fallen to 847 one hundred pound bags of broad beans.

Despite the fact that the broad bean has fallen into disrepute as a human food due to the frequency and severity of weevil infestation, many small garden patches still are grown. Many people relish these beans either as a green or a dry vegetable. Much of the present commercial crop, however, goes into stock feed or is used for cover crop purposes.

INJURY.—Damage caused by the broad bean weevil is due to the fact that the larva feeds and transforms to the adult within the bean. The presence of larvae in the green beans and adults in the dry ones render them unfit for food.

The young larva hatching from the egg bores directly downward through the egg and pod into a developing bean. The entrance hole, or sting, can easily be seen on the green or dry bean as a small dark spot (Fig. 1). It has been estimated that one weevil during its development will consume approximately 3 per cent by weight of the bean.

When full grown the larva cuts a circular window for the subsequent emergence of the adult and then pupates with the bean. The adult can easily push off this circular cap and emerge (Fig. 1). Some adults leave the bean (Fig. 2) as soon as they are developed but others may remain in the bean for a period of several months. Many of the adults emerge after the beans have been planted. There is but one generation per year and broad bean is the only host for this weevil.

The author concurs with Campbell's early statement that could this weevil be controlled, a demand could be recreated for the broad bean as a human food, and a valuable crop could be freely grown once more in the coastal area of California.

Campbell (1919) pointed out that the severity of infestation could be materially reduced by delaying the planting date from October and November to after March 1. This recommendation has not been followed by growers.

Chemical control of this insect has not been practiced by the growers for several important reasons. Prior to the advent

FIG. 1.—Infested broad beans showing entrance holes made by first instar larvae, windows cut by mature larvae and cap pushed aside by emerged adult. ×2.

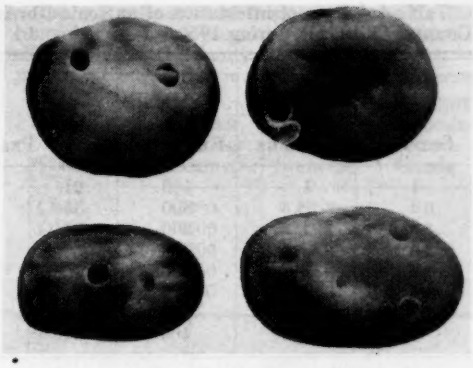

FIG. 2.—Adult broad bean weevil on broad bean. ×6.

of the chlorinated hydrocarbon insecticide such as DDT, there existed no insecticide that would give effective control and still be economically feasible. After these new materials were made available for agricultural use the growers did not know what to use or when to apply it.

Observations and experiments were thus begun, in cooperation with interested growers in San Mateo County, early in 1950 to determine if this pest could be controlled by chemical means.

MATERIALS AND METHODS.—The following dust materials were used in the control studies: 5 per cent DDT plus 50 per cent sulfur; 5 per cent DDT combined with 1 per cent crude benzene hexachloride plus 50 per cent sulfur; 1 per cent lindane; 5 per cent DDT and 2.5 per cent dieldrin. The BHC was added for aphid control.

These materials were applied by rotary hand dusters to small replicated plots and to large fields by a specially equipped helicopter. The small plots were .05 acre in size and were replicated four times. The materials used in the small plot tests were lindane, DDT, DDD and dieldrin.

In the helicopter studies, materials were applied to entire fields ranging in size from 7 to 20 acres.

OBSERVATIONS.—Bean weevils were found hibernating beneath the bark of Eucalyptus trees on March 31, in company with pea weevils at which time several adjacent bean fields were in blossom. One hundred bean tops were shaken over an insect net and 13 weevils were collected. Although small pods were present at this time no eggs could be found. On April 3 an examination of 300 pods revealed the presence of two glistening, milky white eggs glued to the surface of the pod. The largest pod at this time was about 2 inches in length.

On May 24 an examination of 100 pods from untreated field No. 5 revealed a total of 1803 eggs or slightly over 18 per pod. One pod had 57 eggs glued to its surface. At harvest time the beans from this field averaged 1.6 weevils per bean, indicating a larval mortality of about 64 per cent. Untreated field No. 7 gave a

FIG. 3.—A thriving colony of bean aphids on a broad bean plant.

Table 1.—Rate of infestation of untreated broad beans by *Bruchus rufimanus* Boh. in San Mateo County, California during 1950.

Grower	Acreage	Number of Beans Examined	Per Cent Infested				Total Average Per Cent Infested	Average Number Weevils per Bean
1	1	400	91	82	93	87	88.3	2.5
2	.5	300	35	36	35	—	35.3	0.48
3	1.5	300	83	81	76	—	80.0	1.7
4	.5	200	8	25	—	—	16.5	0.2
5	2	400	75	80	81	84	80.0	1.6
6	.5	300	96	93	89	—	92.7	2.1
7	3	400	61	57	49	58	56.3	0.9
8	3	400	37	32	27	31	31.8	0.45

larval mortality of about 50 per cent. These larva mortality figures agree with those given by Campbell (1920).

The first adults emerged from sample beans on August 16 approximately 19 weeks after the first eggs were observed.

On September 20th adults of the broad bean weevil were found again in company with the pea weevil beneath the bark of Eucalyptus, and cypress trees. They were also found behind large splinters on wooden fence posts adjacent to untreated field No. 5. They were found at least 100 yards away from the field.

RESULTS OF INSECTICIDE TESTS.—Eight fields of untreated broad beans were sampled at harvest time to determine the rate of infestation. These represent all of the fields that were readily available in San Mateo County. The results, as given in table 1, show that the rate of infestation varied from a low of 16.5 per cent to a high of 92.7 per cent and averaging 60.1 per cent. Several of the infested fields averaged more than two weevils per bean. One bean was found from which 9 weevils had emerged.

In table 2 are presented the data from five treated fields varying in size from 3.5 acres to 20 acres. These fields were treated by a helicopter under favorable conditions. Treated field No. 1 was separated from untreated field No. 5 by a wire fence. As a result of this proximity a single treatment of 5 per cent DDT+1 per cent benzenehexachloride was not suf-

Table 2.—Rate of infestation of treated broad beans by *Bruchus rufimanus* Boh. in San Mateo County, California during 1950.

Grower	Acreage	Treatment	Rate in Pounds per Acre	Date Applied	Number Beans Examined	Per Cent Infested				Total Average Per Cent Infested	Average Number Weevils per Bean
				1950							
1	8	5% DDT 1% BHC 50% sulfur	50	April 23	400	33	36	36	27	33[1]	0.5
2	20	5% DDT 50% sulfur	25–30	June 10	400	1	1	2	2	1.5%	0.015
3	10	5% DDT 1% BHC 50% sulfur	45–50	April 11	400	0	1	4	2	1.8%	0.02
4	3.5	5% DDT 1% BHC 50% sulfur	45–50	April 11	400	1	1	0	0	0.5%	0.005
5	3.5	5% DDT 1% BHC 50% sulfur	45–50	April 11	400	0	1	0	0	0.25%	0.0025

[1] Immediately adjacent to untreated field number 5 which averaged 80 per cent infested beans.

ficient to give good control. The other four treated fields were remarkably clean at harvest time with average infestation rates of 0.25 per cent to 1.8 per cent.

Some of the beans from the BHC treated fields were tasted by several cooperators for off flavor and none was detected. Additional studies will be made with other aphicides next season.

The results from the small replicated plots are given in table 3. These data show that DDT gave the best control with one application reducing the infestation 53 per cent under the check. DDD and dieldrin also gave promising results but did not seem to be quite as good as DDT.

DISCUSSION.—It appears that one application of 5 per cent DDT properly timed and applied to all broad bean fields in an area will prevent the damage caused by *Bruchus rufimanus* Boh. DDD and dieldrin materially reduced the infestation as compared with the check and deserve further observation.

Inasmuch as the eggs are not affected by these materials, timing of applications to just precede oviposition is critical. The eggs are sufficiently large to be seen with the unaided eye and pod examination will reveal the eggs glued to the surface. Treatment should be applied when one or two eggs can be found on 100 pods.

Due in part to unfavorable dusting weather the treatments on the small plots were applied a few days late. Two days prior to treatment an examination of 50 pods revealed 10 eggs.

Subsequent surveys showed an excellent kill of adults in all treated plots. There was also a reduction of adults in the check plots following treatment. The adult weevil is a very active insect and once it left the small untreated area the probability of its receiving a lethal dose of insecticide was quite high, especially for the first week or two following treatment. Adjacent untreated fields averaged 32 per cent infested beans, while the untreated checks in the small plots showed only 13 per cent at harvest. Larger untreated blocks would have undoubtedly given a more accurate picture.

Table 3.—Results of dust treatments for the control of the broad bean weevil. Small replicated plots, San Mateo County, 20 April 1950.

MATERIAL	NUMBER OF BEANS EXAMINED	PER CENT INFESTED	PER CENT REDUCED UNDER CHECK
Check	1600	12.9	0
DDT	1600	6.1	53
DDD	1600	7.6	41
Dieldrin	1600	7.9	39
Lindane	1600	9.3	28

It is felt that an aphicide should be added not only to control the bean aphid (Fig. 3) which breeds in large numbers on broad bean, but also the less numerous pea aphid. In addition to being the vectors of several virus diseases peculiar to legumes, field observation and unpublished[1] data support the contention that aphid honeydew in combination with high humidity provide a favorable substrate for the growth of *Botrytis cinerea* Pers. This fungus is reported as the cause of the common and destructive "chocolate spot" disease of broad beans.

ACKNOWLEDGEMENTS.—I wish to acknowledge the generous cooperation of the following growers for permitting experimental plots on their crops: Mr. Jesse Nunziatti and Mr. William and Mr. Worden Steele, Pescadero; Mr. Arnold Roach, and Mr. Tony Cardoza, Half Moon Bay. To Julius Hyman Co., Denver, Colorado for the gift of dieldrin dust and to the A. L. Castle Co., Mt. View for formulating dust mixtures. To Professor Roderick Craig for figure 1. And lastly to Mr. Charles Hanson and Mr. William Wade and Mr. R. H. Sciaroni, Farm Advisor, San Mateo County for field assistance.

[1] Dr. William Snyder, Dept. of Plant Pathology in a personal communication.

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The Role of *Chrysolina gemellata* in the Biological Control of Klamath Weed[1,2]

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The use of insects as a means of weed control in North America was first attempted in 1944 with the importation and release of two species of *Chrysolina* which feed on Klamath weed, *Hypericum perforatum* L. This noxious weed is a pest on range lands throughout the temperate regions of the world. It has been particularly troublesome in Australia and in the western part of the United States, where it has depreciated range values by displacing desirable forage plants. In 1943 it was estimated that in California alone about 400,000 acres were infested with Klamath weed. Smith (1947) and Holloway (1948) reported the importation, and the plant feeding tests, which showed that the beetles were restricted to feeding on *Hypericum*. They also reported on the release and establishment of *Chrysolina hyperici* Forst. and *Chrysolina gemellata* (Rossi).

The initial colonies of both species of *Chrysolina* became established, and two years after the first releases were made there was no need of further importation. However, *C. gemellata* has shown a much greater rate of increase in the various climatic areas encountered in California. In one location in Humboldt County 5,000 adult beetles of this species were released in February 1946. During the emergence period of the third generation it was possible to collect thousands of beetles for redistribution, and in 1950 about 3,000,000 adult beetles were collected. The numbers removed were only a very small fraction of the total population present. By that time this colony had spread to the periphery of a 100-square-mile area in which the weed had been brought under very effective control.

At present there are successfully established colonies of *Chrysolina gemellata* in all the 21 counties in California in which Klamath weed is a problem. In some of the older locations in these counties control is already being exerted and is resulting in many acres of dead weeds.

Factors Contributing to Control.—The complete destruction of Klamath weed, a hardy, deep-rooted, perennial herb, can be accomplished only by drastic measures. The plant is resistant to mowing, and although this may lower its vitality, it still persists. It can also survive heavy grazing by sheep or goats, and even though these animals are capable of removing it from the ranges, they do so only after they have eaten away most of the forage species. Plants stripped of nearly all their foliage for a period of 4 or 5 months, or even longer, may recover shortly after the defoliating pressure is removed if sufficient soil moisture is available. Klamath weed seeds are viable in the soil for at least 10 years, according to Bellue (1945). This survival is a factor in the very rapid come back on overgrazed or burned-over ranges.

After about three generations in a locality the beetle larvae become so numerous as to reach a level of mass starvation. Under such conditions the defoliation of the procumbent basal growth is so thorough and prolonged that the photosynthesis of the plant is almost completely curtailed. This feeding takes place during a critical growth phase of the weed, and as a result the root system becomes weakened and the plant dies.

Life history of Chrysolina gemellata *and growth of Klamath weed.*—The detailed life history of this beetle has been reported by Wilson (1943). The gross aspects of the life history are repeated in this paper to show the close relationship of the life cycle of the beetle and the growth phases of the weed under California conditions.

The adult beetles issue during April and early in May from their pupal cells just beneath the soil surface. They feed voraciously on the foliage of the plants, which are producing flower buds or are

[1] This is a cooperative project between the Agricultural Research Administration of the U. S. Department of Agriculture and the California Agricultural Experiment Station.

[2] Presented at the meeting of the American Association of Economic Entomologists, Denver, Colo., December 18–21, 1950.

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actually in flower at that time. By the latter part of June and early in July the fully fed beetles seclude themselves beneath stones and debris and in crevices in the soil. When they find a suitable resting place they go into aestivation for the remainder of the summer. The plant also enters a relatively dormant phase, dropping its leaves and becoming dry and woody.

With the advent of the fall rains both the weeds and the beetles become active. The plant forms a leafy, procumbent basal growth, upon which the active beetles feed sparingly. Then the beetles mate and commence egg laying about mid-October. All stages of the beetle (eggs, larvae, pupae, and adults) are able to withstand winter temperatures. By spring most of the eggs have hatched and the larvae are approaching maturity. The third- and fourth-stage larvae feed on the basal growth, which they completely destroy. Early in the spring the plants that have escaped destruction develop upright shoots which are destined to become the flower-bearing stalks. At that time the larvae complete feeding and enter the soil to the depth of about 1 inch, and each forms a cell in which it pupates. This completes the 1-year life cycle of the insect. The perennial plant has also gone through a complete growth cycle.

Synchronization.—The progress of weed control by this method has now reached a point where success in general may be assigned to the action of *Chrysolina gemellata*, and the primary reasons for assumption of the dominant position by this species over *C. hyperici* have become apparent. The balance between the propagative ability of the weed and that of its insect enemy is the result of forces exerted upon both by factors of soil condition, meteorological circumstances, and the associated living environment. The biological control of this weed is a striking example of this principle. The two species of *Chrysolina* differ only slightly in their environmental requirements. Yet that small difference permits the enormous multiplication of the one species and curtailment of the other.

In general, the growth phases of the plant and the climate in Klamath weed areas in California are very favorable to *Chrysolina gemellata* and unfavorable to *C. hyperici*. After the fall rains begin, the weed develops a dense, prostrate rosette of basal foliage. *C. gemellata* readily comes out of aestivation and begins to reproduce immediately, whereas *C. hyperici* reacts to moisture very slowly. As a result of this delay, the latter species is deprived, by this lack of synchronization, of opportunity for propagation at a season of the year when the plant's growth is in ideal condition. *C. gemellata* deposits the bulk of its eggs in the fall and early in the winter, and its larval brood is often at an advanced stage of development by the time *C. hyperici* begins to oviposit in quantity.

As a result of its delay of reproductive activities in the fall, the developmental phase of the brood of *Chrysolina hyperici* is projected so far into the summer that the dry soil conditions that prevail from about April to October destroy the great mass of the population. Because of its failure to utilize the full annual span of moist conditions and favorable temperatures, *C. hyperici* does not have sufficient time left to complete its development. Only individuals from the very first eggs deposited or those able to locate the limited number of favorable moisture niches are able to mature. The total effective egg-laying period of this species is thereby reduced to a very small fraction of what it would be if the beetles came out of aestivation early in the fall, or if ample rainfall were prolonged later into the spring. Huge egg and larval populations of this species late in the spring produce rather insignificant numbers of adult beetles. No significant parasitic or predatory action has been observed; and, furthermore, such agents would hardly be expected to operate selectively to the disadvantage of *C. hyperici*, as compared with its very close relative, *C. gemellata*.

In one highland area of Humboldt County, where moist conditions are prolonged much later in the spring than in other weed-infested areas, even *Chrysolina hyperici* has rapidly increased and is controlling the weed. An experiment was carried out which further proves this point. Irrigation from mid-August to November of an area that had been colonized by this species was conducive to production of a very large population of eggs in the fall and early winter and successful emergence of proportionate num-

bers of adults the following spring. Multiplication in this area was comparable to that of *C. gemellata* under natural field conditions. The locality where this test was made has a climate very similar to that of an adjacent location that has been notably inimical to the natural multiplication of this species.

The factor of dry soil and its effect on the maturing population during the spring months was tested in the laboratory. A total of 50 larvae, 10 per can of soil, were used for each test. Six ounces of sun-dried soil was used in each can. The required moisture was added to the cans and the soil was either "firmed" or left loose, as indicated in table 1, and an air-tight lid was placed on each can. At the end of the trials the soil was again weighed and it was found that the loss of moisture in the cans had been negligible. Sphagnum moss was used as a surface mulch in one can. Sand was added to the soil in one can, to see whether the change in texture would appreciably influence the results.

These tests (Table 1) proved conclusively that *Chrysolina hyperici* larvae are unable to enter a perfectly dry soil, whether or not it contains a high proportion of sand. Also, if the soil is only slightly moist, many of the larvae are able to enter the soil but only a small percentage emerge. Only with ample soil moisture do the larvae enter the soil, pupate, and successfully emerge as adults.

Table 1.—Effect of moisture and texture of soil on entrance, pupation, and emergence of *Chrysolina hyperici*.

Condition of Soil[1]		Burrowed in Soil	Emerged
Moisture Added	Texture		
Per Cent		*Per Cent*	*Per Cent*
	Laboratory-reared Insects		
None	Firm	2	0
3	Firm	20	0
3	Firm, sphagnum on surface	18	0
6	Firm	72	22
15	Firm	100	62
	Field-collected Insects		
6	Firm	82	42
15	Firm	98	80
6	Loose	98	68
6	Firm, 50% sand	100	60

[1] The sun-dried soil was taken as the base for calculation of percentage moisture added.

Natural beetle dispersion.—The dispersal of *Chrysolina gemellata* has been closely observed under California conditions. During the early stages of an initial colonization, the beetles move outward from a release center primarily by walking. Preaestivating adults in such an environment, where food is abundant, exhibit little inclination to fly or to walk. However, after aestivation they walk rather rapidly, laying eggs as they progress outward. During the first winter following a release, eggs have commonly been found for a distance of 50 to 100 yards from a release center. A progressive decrease in the numbers of eggs and larvae is common as the distance from a release site increases. Some plants at the original sites were slow to develop in the fall, owing to poor exposure or otherwise, and therefore the beetles moved away. The heaviest concentrations of eggs were then found in nearby vicinities that supported favorable plant growth early in the fall.

On the other hand, if a population has reached an advanced stage in a certain infested field and the larvae have defoliated nearly all the weeds, the issuing adults may be stimulated to flight by their hunger and by the bright sunlight on warm days. Colonies have appeared as far as 3 miles away from a parent colony—it is suspected by this means.

Natural movement of the beetles has proceeded at a rapid rate after the third or fourth years. The third generation, 2 years after liberation of beetles at Blocksburg, removed the weed for a distance of 100 yards. By the following year, 1949, the beetles had moved outward and almost cleared a continuous area a mile in every direction from the release site. In 1950 this control area had been increased, primarily through the agency of natural dispersion, to an area of about 100 square miles and extending to points 6 or 8 miles distant.

OUTLOOK FOR CONTROL.—It is expected that control of the weed by *Chrysolina gemellata* will progress rapidly, and that many of the 21 California counties that now have beetle colonies will shortly have striking increases in the acreage of weed brought under control. The ultimate result from the effort will, of course, depend on many factors, such as competition from other range plants, reinfestation by Klamath weed seedlings, the

ability of the beetles to survive on very small patches of weed, their ability to locate new infestations, and the possible appearance of natural enemies of the beetles themselves.

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Control of Insect Larvae Infesting Immature Blueberry Fruit

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In New Jersey the immature fruit of cultivated blueberries is commonly infested by the larvae of the cranberry fruitworm, *Mineola vaccinii* (Riley), the cherry fruitworm, *Grapholitha packardi* Zeller, and the plum curculio, *Conotrachelus nenuphar* (Herbst.). Infestations of the two fruitworms vary from year to year and from field to field and apparently are of a cyclic nature. The plum curculio has only recently become troublesome. It has shown a rather steady and consistent increase during the last six seasons until it is now among the most serious insect pests of immature fruit in several New Jersey blueberry fields.

Larvae of both of the fruitworms feed in several berries in the cluster before maturing, so that only a few worms may destroy many berries. Plum curculio grubs feed in one berry only, but may be so numerous that they destroy at least as many berries as the fruitworms do.

Though the actual crop loss from these three pests can be and often is serious, of equal importance is the fact that the larvae of all three species are still present in the fruit of early pickings. No matter how carefully early shipped berries from infested fields are picked and packed, fruitworm larvae get into the shipments and crawl about under the cellophane, where they are easily seen by the buyer. Plum curculio grubs are not ordinarily seen by the consumer until after the berries are purchased and the grubs have left the berries and are noted crawling around the bottom of the refrigerator, or swimming around on top of the milk or cream when the berries are eaten.

The length of the blooming period of blueberries varies somewhat according to weather conditions and variety, but usually extends over 3 to 4 weeks on individual bushes. For that reason, berries that set first start to grow and attain fair size before the last of the bloom has dropped.

Cranberry fruitworm and plum curculio start to lay eggs as soon as the first few berries have set and start to grow. Trapping of cherry fruitworm moths during 1950 with the standard oriental fruitworm moth bait indicated that moth flight and egg deposition of the cherry fruitworm do not occur in abundance until near the close of blueberry bloom.

Failure of the pyrethrum dust recommended by Beckwith (1941) to control fruitworm infestations during the 1946 and 1947 seasons, and increasing trouble from plum curculio, led to the spray experiments during 1948, 1949, and 1950 which are reported in this paper.

In 1948, plots were sprayed in a blueberry field at Pomona, N. J., because this field was known to be heavily infested with cranberry fruitworms in 1947. Cryolite was used because it was shown by

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rurgers University—the State University of New Jersey, Division of Horticulture.
Eastern Branch Program—1950.

Table 1.—Cranberry and cherry fruitworm spray tests at Pomona, N. J., in 1948.[1]

Materials per 100 Gallons of Spray	Cranberry Fruitworm			Cherry Fruitworm		
	Total Larvae	Larvae per Pt.	Per Cent Reduction	Total Larvae	Larvae per Pt.	Per Cent Reduction
50% wettable DDT—2 lbs.	79	6.5	74.7	329	27.4	33.4
Cryolite—4 lbs.	34	2.8	89.1	91	7.4	81.6
Check—none	313	26.08		494	41.2	

[1] Spray applied May 20 and 27.

Franklin (1940) to be effective for controlling cranberry fruitworm on cranberries, and DDT was used because it was shown by Fulton (1946) to be effective on blueberries. The plots consisted of 20 mature blueberry plants, 10 in each row of a double row of Cabot plants near the edge of the field. The first application of 4 pounds of cryolite or 2 pounds of 50 per cent wettable DDT per 100 gallons was made to two such plots on May 20, and one of the plots was sprayed a week later with the same materials to give a single and a double application. Enough spray was applied to wet the bushes thoroughly.

Results of the sprays are calculated from the number of larvae emerging from 12-pint berry samples picked at random in the plots, just prior to the first regular picking by the grower. Both green and ripe fruit were included in the samples. This sampling procedure was also followed in 1949 and 1950 in all plots. Where plots were replicated, an equal volume of fruit was picked from each of the plots to make up the 12-pint sample for that treatment.

Single applications, though producing some reduction of fruitworms, have never been satisfactory; therefore, only results with two applications are discussed in this paper. Table 1 shows that in 1948 two applications of cryolite reduced the cranberry fruitworm infestation 89 per cent, while two applications of DDT reduced the infestation 74 per cent.

The presence of cherry fruitworms in the 1948 samples came as a surprise, since this fruitworm had not been noted in abundance in this field in 1947. DDT did not control this species, but cryolite reduced the infestation 81 per cent.

It was noticed that cryolite-sprayed berries were smaller, drier and harder than unsprayed fruit. Cryolite also pro-

Table 2.—Cranberry and cherry fruitworm spray tests at Pomona, N. J., in 1949.[1]

Materials per 100 Gallons	Cranberry Fruitworm			Cherry Fruitworm		
	Total Larvae	Larvae per Pt.	Per Cent Reduction	Total Larvae	Larvae per Pt.	Per Cent Reduction
50% methoxychlor—2 lbs.	1	0.1	90	64	5.3	65.4
50% methoxychlor—2 lbs. 12% Lindane—28 oz.	0	0	100	136	11.3	26.5
50% methoxychlor—2 lbs. 15% parathion—24 oz.	0	0	100	73	6.1	60.5
Cryolite—4 lbs.	0	0	100	110	9.2	40.5
Rotenone—4 lbs.	4	0.33	60	229	19.0	0
12% Lindane—32 oz.	10	0.83	0	199	16.6	0
25% Toxaphene—4 lbs.	1	0.1	90	108	9.0	41.6
50% DDT—2 lbs.	3	0.25	70	122	10.2	34.1
50% DDT—2 lbs. 12% Lindane—32 oz.	0	0	100	136	11.3	26.5
50% TDE—2 lbs.	2	0.17	80	72	6.0	61.1
15% parathion—24 oz.	3	0.25	70	102	8.5	44.9
Check—none	10	0.83		185	15.4	

[1] Sprays applied May 6 and 17.

Table 3.—Cherry fruitworm spray test at Pomona, N. J., in 1950.[1]

Materials and Amounts per 100 Gallons of Spray	Total Larvae	Larvae per Pt.	Per Cent Reduction
50% methoxychlor—3 lbs.	82	6.83	74.22
50% methoxychlor—2 lbs. 25% aldrin—1 lb.	159	13.25	50.00
50% methoxychlor—2 lbs.[2]	55	5.58	82.71
50% TDE—3 lbs.	42	3.56	86.8
EPN 300[3]—2 lbs.	51	4.25	83.97
25% aldrin—2 lbs.	243	20.25	23.59
100% Ryania—6 lbs.	288	24.00	9.4
Emulsifiable CPR Liquid[4]—2 qts.	161	13.41	49.38
Check—none	318	26.5	

[1] Sprays applied on May 22, 31, and June 8.
[2] Samples of berries taken from larger block sprayed by owner.
[3] 27% Ethyl para nitrophenyl thionobenzenephosphonate (du Pont).
[4] U. S. Industrial Chemicals, Inc.

duced a chlorosis of the foliage on sprayed plants. No such symptoms were produced by the DDT spray.

In 1949 similar plots were sprayed in this same field on May 6 and 17. Several more insecticides were included in the tests than in 1948. A marked natural decline of the cranberry fruitworm occurred in this field, as evidenced by counts in the check plots, where there were less than 1 per pint compared to 26 in 1948. Cherry fruitworms were also less abundant, but still averaged 15 larvae per pint in the unsprayed check plots. Table 2 summarizes the results of the 1949 sprays.

Table 4.—Plum curculio spray test near Chatsworth, N. J., in 1949.[1]

Materials and Amounts per 100 Gallons of Spray	Total Grubs	Grubs per Pt.	Per Cent Reduction
15% Parathion—24 oz.	31	2.58	0
Lead arsenate—4 lbs.	19	1.58	36.6
Tech BHC (6% Gamma)—3 lbs.	15	1.25	50.0
12% Lindane—24 oz.	38	3.16	0
50% Chlordan—2 lbs.	7	0.58	76.6
25% Aldrin—2 lbs.	8	0.66	73.3
Cryolite—4 lbs.	39	3.25	0
Check—none	30	2.5	

[1] Sprays applied May 13 and 19.

It will be noticed that TDE and methoxychlor gave the best control of cherry fruitworm. Cranberry fruitworms were so scarce that the results are probably not significant, but these same materials were also among the best against this species. Cryolite-sprayed plots again showed fruit and foliage injury similar to that of the previous season.

In 1950 plots in this same field were again sprayed with some of the most promising materials from 1949 plus a few new ones. Sprays were applied on May 22, 31, and June 8. Cranberry fruitworms were entirely absent from all plots, whereas cherry fruitworms showed a slight increase over 1949. As shown in table 3, EPN 300, TDE, and methoxychlor gave the best control. Aldrin, Ryania, and emulsifiable CPR liquid were not effective against the cherry fruitworm.

In 1949 several insecticides were tested

Table 5.—Cranberry fruitworm, cherry fruitworm and plum curculio spray tests near Chatsworth, N. J., 1950.[1]

Material and Amount per 100 Gallons	Cranberry Fruitworm			Cherry Fruitworm			Plum Curculio		
	Total Larvae	Larvae per Pt.	Per Cent Reduction	Total Larvae	Larvae per Pt.	Per Cent Reduction	Total Larvae	Larvae per Pt.	Per Cent Reduction
Alloway									
40% Chlordane—2.5 lbs.	34	2.83	0	140	11.66	12.5	17	1.41	77.64
50% Methoxychlor—2 lbs. Lead arsenate—2 lbs.	12	1.0	62.5	62	5.16	61.25	9	0.75	88.16
Emulsifiable CPR liquid[2]—2 qts.	14	1.16	56.25	172	14.33	0	50	4.16	34.22
Check—none	32	2.66		160	13.33		76	6.33	
Evans & Wills									
25% Aldrin—2 lbs.	11	0.91	8.34	268	22.33	0	43	3.58	90.95
50% Methoxychlor—3 lbs.	3	0.25	75.00	21	1.75	90.87	23	1.91	95.16
50% Methoxychlor—2 lbs. Lead arsenate—2 lbs.	2	0.16	83.34	13	1.08	94.35	9	0.75	98.11
Lindane 12% gamma—2 lbs.	6	0.50	50.00	177	14.75	23.05	135	11.25	71.58
Check—none	12	1.0		230	19.16		475	39.56	

[1] Alloway sprayed June 5 and 12.
Evans & Wills sprayed June 2 and 9.
[2] U. S. Industrial Chemicals, Inc.

in small plots of Concord bushes in a field near Chatsworth, N. J., against the plum curculio. Sprays were applied on May 13 and 19, the first application being put on when about 90 per cent of the bloom of this variety had dropped. Table 4 summarizes the results of this test. Chlordane and aldrin gave the same degree of control; all other materials were disappointing. The failure of some of these materials may be a reflection on the plot size or improper timing, rather than ineffectiveness of the insecticides.

Since results from such small plots indicated, at best, the relative effectiveness of the different insecticides only, larger plots (at least 1 acre) were sprayed in two fields near Chatsworth, N. J., in 1950 to evaluate methoxychlor and some other materials on a field scale for controlling cherry fruitworm, cranberry fruitworm and plum curculio. The sprays were applied on June 2 and 9 to one field and on June 5 and 12 to the other, the first spray on each field being applied when 75 per cent of the bloom had set. Sprays were applied at the rate of about 200 gallons per acre.

Table 5 summarizes the results in these larger plots. Methoxychlor alone and methoxychlor combined with lead arsenate gave very substantial reductions of both cherry and cranberry fruitworms and of plum curculio. None of the other insecticides was satisfactory against all three species. On the basis of these results and because of its comparative safety for grower use in 1951, we are recommending 3 pounds of 50 per cent wettable methoxychlor to be applied at the rate of 200 gallons per acre, when 75 per cent of the bloom has set, and again 7 to 10 days later.

SUMMARY.—The larvae of the cranberry fruitworm, cherry fruitworm and plum curculio cause serious losses of cultivated blueberries, both in the field and in the packaged fruit in New Jersey. Experiments in 1948 and 1949 indicated that cryolite injured the fruit to such an extent that it was impractical to use, even though it showed promise for controlling the two fruitworms. DDT was effective against the cranberry fruitworm but not against the cherry fruitworm. Methoxychlor exhibits a marked toxicity to all three of the insects and because of its comparative safety and effectiveness is the one recommended for use at this time.

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Insecticidal Effectiveness of Aerosols and Sprays Containing Esters of Synthetic Cyclopentenolones with Natural Chrysanthemum Monocarboxylic Acid

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Tests against house flies, mosquitoes, and cockroaches with the completely synthetic allyl homolog of cinerin I, now called allethrin, have been reported (Fales *et al.* 1951). Before this ester was available, considerable work had been completed with two esters, one prepared from the allyl and the other from the methylallyl cyclopentenolone esterified with the natural *d-trans*-chrysanthemum monocarboxylic acid—(1) the *dl*-2-allyl-4-hydroxy-3-methyl-2-cyclopenten-1-one ester and (2) the *dl*-4-hydroxy-3-methyl-2-(2-methylallyl)-2-cyclopenten-1-one ester. These natural-acid esters are optically active, whereas allethrin is inactive. Tests with these two natural-acid esters, called briefly the allyl and methylallyl esters, are reported in this paper. The insects and methods used were the same as in the tests with allethrin. All tests were made in a Peet-Grady chamber.

COMPARISONS OF THE NATURAL-ACID ESTERS WITH PYRETHRINS.—Comparisons

Table 1.—Comparison of two natural-acid esters and pyrethrins in aerosols and sprays against house flies. Average of four tests each.

Material	Per Cent Knockdown in Minutes			Per Cent Kill in 1 Day
	5	10	15	
Aerosols:				
Allyl ester	81	95	99	79
Methylallyl ester	51	80	93	45
Pyrethrins	65	83	90	49
Sprays:				
Allyl ester	95	99	—	60
Methylallyl ester	98	99	—	40
Pyrethrins	91	94	—	30

Table 2.—Comparison of allyl ester, allethrin, and pyrethrins in aerosols and sprays against house flies.

Material	Per Cent Knockdown in Minutes			Per Cent Kill in 1 Day
	5	10	15	
Aerosols (6 tests):				
Allyl ester	84	93	99	75
Allethrin	61	83	92	53
Pyrethrins	64	79	86	44
Sprays (5 tests):				
Allyl ester	82	91	—	69
Allethrin	65	82	—	39
Pyrethrins	75	83	—	40

of the two natural-acid esters with natural pyrethrins were made against house flies, *Musca domestica* L. and common malaria mosquitoes, *Anopheles quadrimaculatus* Say. In the house fly tests the materials were used in both high-pressure aerosols and sprays. In tests with mosquitoes only sprays of the allyl ester were compared with the pyrethrins.

The aerosols used contained 1 per cent of the ester or 5 per cent of a 20 per cent pyrethrum extract. Methylene chloride at 10 per cent was used with the esters and at 6 per cent with the pyrethrum extract. The propellant, *Freon-12*, made up the remaining 89 per cent of these formulations. The aerosols were tested at a dosage of 4.63 grams per 1000 cubic feet.

For the house fly tests, the sprays were made up to contain 1 mg. of ester or pyrethrins per milliliter of deodorized kerosene. They were tested at 55.56 ml. per 1000 cubic feet.

For tests against mosquitoes the sprays were made to contain 0.2 mg. of active ingredient per milliliter of deodorized kerosene, and the dosage was 9.26 ml. per 1000 cubic feet. Three replications were made in this series.

Table 1 shows that in both aerosols and sprays the methylallyl ester was about equal to the pyrethrins against house flies, whereas the allyl ester was superior.

The allyl ester was also better than the natural pyrethrins against mosquitoes, killing 100 per cent of the males and 83 per cent of the females in 1 day, compared with 98 per cent of the males and 72 per cent of the females for the pyrethrins.

COMPARISON OF THE ALLYL ESTER, ALLETHRIN, AND PYRETHRINS.—When allethrin became available, it was compared with the natural-acid allyl ester and with pyrethrins in both high-pressure aerosols and sprays against house flies. The allethrin aerosol contained 1 per cent of the ester, 4 per cent of deodorized kerosene, 6 per cent of methylene chloride, and 89 per cent of *Freon-12*. The allyl ester and pyrethrum aerosols were made as described for the previous tests. The dosages were also the same as in the previous tests. The aerosol and spray tests are summarized in table 2. It is evident that the allyl ester is more effective than allethrin or the pyrethrins.

The same aerosol containing the allyl ester was then tested against house flies at four dosages. The results are shown in figure 1.

After being stored under room conditions for 8 months, the aerosol containing the allyl ester at the same dosage as used in table 1 caused 99 per cent knockdown

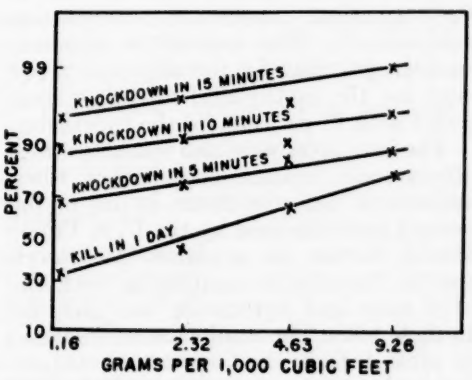

FIG. 1.—Knockdown and kill of house flies obtained with different dosages of the synthetic allyl ester made with natural acid in a *Freon-12* aerosol.

Table 3.—Effect of substituting the synthetic esters for the natural pyrethrins in an aerosol in tests against house flies. Aerosol formulas: Synthetic ester or pyrethrins 0.4, DDT 3, cyclohexanone 5, lubricating oil 5, deodorized kerosene 1.6, *Freon-12* 85 per cent. Average of 3 tests at 1.16 grams of aerosol per 1000 cubic feet.

Ester or Pyrethrins	Per Cent Knockdown in Minutes			Per Cent Kill in 1 Day
	5	10	15	
Allyl ester	61	72	85	93
Methylallyl ester	55	73	85	94
Pure natural pyrethrins	16	37	52	88
Pyrethrins from pyrethrum extract	20	44	61	93

of house flies, in 15 minutes and 76 per cent kill in 1 day, compared with 85 per cent knockdown and 48 per cent kill for the natural pyrethrins. Comparison of these figures with those in table 1 indicates no loss in performance due to storage.

Effectiveness of the Synthetic Esters in Practical Aerosol Formulas.—The effectiveness of the synthetic esters when substituted for natural pyrethrins in practical aerosol formulas was also studied.

The results of tests with a typical high-pressure aerosol against house flies are summarized in table 3. Both esters caused an increase in knockdown, and gave mortalities equal to that for the standard formulas, one of which was made with pure pyrethrins rather than pyrethrum extract.

The same aerosols containing the synthetic esters and the pure pyrethrins were also tested against large nymphs of the American cockroach, *Periplaneta americana* L. The mortalities obtained were 53 per cent for the allyl and 3 per cent for the methylallyl esters as compared with 17 per cent for the pyrethrins.

The two esters were also tested for their effectiveness against cockroaches when substituted for pyrethrum in one of the aerosol formulas used by the U. S. Public Health Service on airplanes. An experimental formulation containing both the allyl ester and pyrethrum was included in these tests. The results are summarized in table 4. Only the formulation containing both pyrethrum extract and the allyl ester was equal to the regular formula.

This aerosol was given a more critical evaluation against house flies in tests by the swinging-shutter method. The results are shown in table 5, series I. The increased effectiveness of the combination of pyrethrum and the allyl ester is evident. Another formula, containing 4 per cent of the ester, was then tried (Table 5, series II), and it appeared to be one of the most effective aerosols yet tested. When used against large nymphs and adult females of the American cockroach at 23.15 grams per 1000 cubic feet, it gave 100 per cent mortality of both stages, whereas the formula without the ester killed only 57 per cent of the nymphs and 28 per cent of the adults.

Table 4.—Effect of substituting the synthetic esters for pyrethrum in a U. S. Public Health Service aerosol formula and of adding the allyl ester to this formula in tests against American cockroaches. Average of 2 tests at 23.15 grams of aerosol per 1000 cubic feet.

Aerosol Formula	Per Cent Concentration	Per Cent Kill in 5 Days	
		Adult Females	Large Nymphs
Allyl ester	1	45	25
DDT	3		
Cyclohexanone	5		
Deobase	4		
Lubricating Oil	2		
Freon-12	85		
Methylallyl ester	1	5	16
DDT	3		
Cyclohexanone	5		
Deobase	4		
Lubricating oil	2		
Freon-12	85		
Pyrethrum extract (20%)	5	100	30
DDT	3		
Allyl ester	1		
Cyclohexanone	5		
Lubricating oil	1		
Freon-12	85		
Public Health Service			
Pyrethrum extract (20%)	5	85	20
DDT	3		
Cyclohexanone	5		
Lubricating oil	2		
Freon-12	85		

Summary.—The insecticidal effectiveness of two pyrethrin-type esters, the allyl- and the methylallyl-substituted cyclopentenolones esterified with natural *d-trans*-chrysanthemum monocarboxylic acid, was tested in sprays and aerosols in a Peet-Grady chamber.

In both sprays and aerosols the methylallyl ester was about equal to natural pyrethrins and to the completely synthetic pyrethrin-type ester (allethrin) when tested against house flies. The allyl ester was considerably more effective against house flies than the methylallyl ester or the natural pyrethrins.

Table 5.—**Effect of combining the allyl ester with a U. S. Public Health Service aerosol, in swinging-shutter tests against house flies.**

Aerosol Formula	Per Cent Concentration	Grams of Aerosol per 1000 Cubic Feet	Per Cent Knockdown in Minutes			Per Cent Kill in 1 Day
			5	10	15	
		Series I (Average of 3 tests)				
Pyrethrum extract (20%)	5	0.33	52	81	85	87
DDT	3					
Allyl ester	1					
Cyclohexanone	5					
Lubricating oil	1					
Freon-12	85					
Pyrethrum extract (20%)	5	.34	8	23	36	67
DDT	3					
Cyclohexanone	5					
Lubricating oil	2					
Freon-12	85					
		Series II (average of 2 tests)				
Pyrethrum extract (20%)	5	.20	52	82	88	85
DDT	3	.39	84	96	98	98
Allyl ester	4					
Cyclohexanone	5					
Freon-12	83					
Pyrethrum extract (20%)	5	.20	8	14	20	52
DDT	3	.39	12	27	37	71
Cyclohexanone	5					
Lubricating oil	2					
Freon-12	85					

In sprays the allyl ester was more effective against mosquitoes than the natural pyrethrins.

The allyl ester in an aerosol gave house fly knockdown and mortality curves similar to those given by natural pyrethrins.

An aerosol containing the allyl ester was stored for 8 months without loss in effectiveness.

In high-pressure aerosols both esters at 0.4 per cent were equally as effective against house flies as pyrethrum extract and pure natural pyrethrins, but were not effective against American cockroaches. The addition of 1 or 4 per cent of the allyl ester to one of the U.S. Public Health Service aerosol formulas gave the most effective aerosols yet tested against house flies and American cockroaches.

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The L. O. Howard Obituary

Readers of the Journal have enquired concerning the authorship of the splendid obituary article published in the December, 1950, number of the Journal without the name of the Author.

The obituary was written by Dr. F. C. Bishopp, of the Bureau of Entomology and Plant Quarantine and we are informed that it was the expressed wish of Dr. Howard, before his death, that Dr. Bishopp, his long-time friend and colleague perform this service.

SCIENTIFIC NOTES

Toxicity of Some Organic Insecticides to Screw-Worm Larvae[1]

GAINES W. EDDY, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During the last few years a large number of chlorinated hydrocarbons have been tested as insecticides by various research agencies. Some of the materials have been found to be highly toxic to certain species of insects and have become popular commercial insecticides. Most of the more promising of these materials have been tested in the laboratory against larvae of the screw-worm, *Callitroga americana* (C. and P.). Tests with some of them and also parathion and diphenylamine, which are not chlorinated hydrocarbons, are discussed in this paper. Parathion was included because of its high toxicity to screw-worm larvae, and diphenylamine because it is the main wound protector in *Smear 62*, now recommended for the control of screw-worms.

PROCEDURE.—For tests against newly hatched larvae the methods described by Eddy & Graham (1950) were used. Various amounts of the insecticide dissolved in a 9:1 mixture of acetone and a polyoxylakalene derivative of sorbitan monolaurate,[2] were added to a nutritive medium, and after it had been warmed for about an hour at 90° F. 25 newly hatched larvae were introduced. The cultures were held at this temperature and a relative humidity of approximately 85 per cent. Mortality of the larvae was recorded after 24 and 48 hours.

For tests against full-grown larvae acetone solutions of the various materials were prepared and the larvae immersed in them. Twenty to 50 larvae were used per test. The results presented represent an average of six tests. The larvae were placed in a 50-ml. beaker and allowed to remain in the solution for approximately 10 seconds. The solution was then poured through a small piece of wire screen and the larvae were dumped on paper toweling and then transferred to moistened sand for pupation. The mortality caused by the insecticides was computed from the percentage of flies reared from each treated culture.

RESULTS.—The results of tests against both newly hatched and full-grown larvae are shown in table 1.

Against full-grown larvae parathion was the most toxic material tested, but there was not much difference in toxicity between this material and dieldrin. Both parathion and dieldrin were slightly more toxic than lindane. In some tests parathion and dieldrin killed all these larvae at 0.05-per cent concentration. Aldrin, heptachlor, and *Compound 153*[3] were about equal in toxicity. They were definitely less toxic than parathion, dieldrin, or lindane, but more toxic than the other materials tested. Chlordane and toxaphene were less toxic, but considerably more toxic than diphenylamine, DDT, methoxychlor, or TDE. Although these four materials did not kill all the larvae at 10 per cent concentration, diphenylamine at 30 per cent caused high but incomplete kill of larvae. None of the materials tested thus far which were closely related to DDT have proved highly toxic to full-grown screw-worm larvae.

Against newly hatched larvae parathion was also the most toxic material, causing complete mortality of the larvae in 48 hours at a concentration of 0.0001 per cent. Lindane was the next most toxic material, but only slightly more so than dieldrin, aldrin, heptachlor, or DDT. Diphenylamine and *Compound 153* were less toxic than the above-mentioned materials, but more toxic than methoxychlor or TDE. Toxaphene and chlordane appeared to be about as toxic as diphenylamine. Parathion, lindane, dieldrin, aldrin, and heptachlor affected growth of the larvae at concentrations considerably lower than those necessary to cause complete mortality in 48 hours. This was not true of chlordane, methoxychlor, or diphenylamine.

Table 1.—Toxicity of some organic insecticides to screw-worm larvae. The higher concentration in each column caused 100-per cent mortality, but the lower concentration did not.

MATERIAL	NEWLY HATCHED	FULL-GROWN
Parathion	0.00005–0.0001	0.05–0.1 (98)
Dieldrin	0.005 –0.01	0.05–0.1 (90)
Lindane	0.001 –0.005	0.05–0.1 (76)
Aldrin	0.005 –0.01	0.1 –0.25
Heptachlor	0.005 –0.01	0.1 –0.25
Compound 153	0.01 –0.05	0.1 –0.25
Chlordane	0.01 –0.1	0.5 –1.0
Toxaphene	0.01 –0.1	0.5 –1.0
Diphenylamine	0.01 –0.05	>10
DDT	0.005 –0.01	>10
Methoxychlor	0.01 –0.1	>10
TDE	0.01 –0.1	>10

[1] Figures in parentheses indicate per cent mortality at lower concentration.

DISCUSSION.—In the tests against newly hatched larvae, where the insecticide was incorporated with a nutritive medium, the materials had an opportunity to act as stomach poisons, contact insecticides, or perhaps as fumigants. In the tests against full-grown larvae, the materials probably acted chiefly as contact insecticides, since the larvae had little opportunity to ingest the materials. Some materials, such as DDT, were highly toxic to newly hatched larvae but relatively nontoxic to full-grown larvae.

Before any of these materials are recommended for use in screw-worm treatments, factors other than their toxicity in the laboratory must be considered. Some of these factors will be determined by tests on the animal's wound. It is believed that materials effective against full-grown larvae are more likely to make better wound treatments than those that are effective only against newly hatched larvae.

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[1] Presented at Texas Entomological Society meetings held at Houston, Texas, January 18–20, 1950.

[2] *Tween-20*.

[3] 1,2,3,4,10,10-hexachloro-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethanonaphthalene.

A Granulosis of the Imported Cabbageworm[1]

CLARENCE G. THOMPSON, *University of California, Berkeley*

A granulosis disease similar to those found in certain other insects such as the variegated cutworm, *Peridroma margaritosa* (Haw.), and the buckeye caterpillar, *Junonia coenia* Hübner, has been discovered in larvae of the imported cabbageworm, *Pieris rapae* Linn. The diseased caterpillars appeared in the second generation of insectary stock which originally came from adult female *Pieris* collected in Albany, California.

As the disease progresses, infected larvae become much paler than normal. Just before death, the caterpillars appear uniformly milky-yellow on the dorsal and lateral surfaces while the ventral surface is almost white. Soon after death the cadavers turn a mottled black and then entirely black.

All of 30 individually reared larvae died in from seven to eight days after they were infected by feeding them mustard leaves which had been dipped in a water suspension of virus material.

Upon dissection, the fat tissue of infected larvae has an opaque white appearance as compared to the straw-colored and nearly transparent fat bodies of normal larvae. The whitish appearance of the diseased caterpillars appears to be caused by the presence of numerous granules floating free in the body fluid of the insects. Electron microscopy of the granules and virus particles shows the same general appearance and structure of these bodies as those found in other granulosis virus diseases.[2]

In cross-infectivity tests, the buckeye caterpillar, the variegated cutworm (the species indicated above), the omnivorous looper, *Sabulodes caberata* Guenée, and the salt-marsh caterpillar, *Estigmene acraea* Drury, proved to be insusceptible to the granulosis of the imported cabbageworm. These are the only other insects occurring in California in which granuloses are now known to occur. No infection could be produced in *Pieris* by feeding viruses from these other insects.

[1] Contribution from the Laboratory of Insect Pathology, Division of Biological Control, College of Agriculture, University of California, Berkeley 4, California.

[2] Virus preparation and electron microscopy by K. M. Hughes.

Field Tests During 1950 Using a Polyhedrosis Virus to Control the Alfalfa Caterpillar[1]

CLARENCE G. THOMPSON, *University of California, Berkeley*

The polyhedrosis of the alfalfa caterpillar, *Colias philodice eurytheme* Boisduval, is an important factor in the natural reduction of populations of the insect. During the past three years 21 field tests have been conducted using the virus as a control agent. Eighteen of these were on 1-acre plots and 3 were 40-acre fields. The virus, *Borrelina campeoles* Steinhaus, was applied by a back-pack sprayer on the small plots and by airplane on the 3 fields. The results of the 1948 and 1949 field tests (Steinhaus & Thompson, 1949; and Thompson & Steinhaus, 1950) together with those of the 1950 field tests furnish rather conclusive evidence that artificial dissemination of the virus can be dependably used to produce epizootics of the disease in field populations of the alfalfa caterpillar. These artificially induced epizootics result in almost 100 per cent mortality of the caterpillar population.

[1] Contribution from the Laboratory of Insect Pathology, Division of Biological Control, College of Agriculture, University of California, Berkeley 4, California.

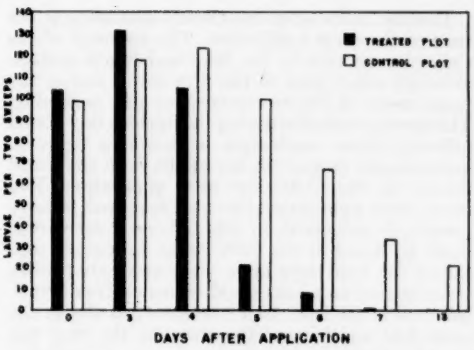

FIG. 1.—The larval populations during the 13 day period following virus application. 1950 test No. 2.

In order to demonstrate the mortality induced in a field population of the alfalfa caterpillar by the application of the virus, 1950 field test No. 2 may be used as a typical example. This test was made on a 40-acre field on the Redfern ranch near Dos Palos, California. Five gallons of virus suspension (in water) containing 10,000,000 polyhedra per milliliter was applied per acre. Application was by airplane.

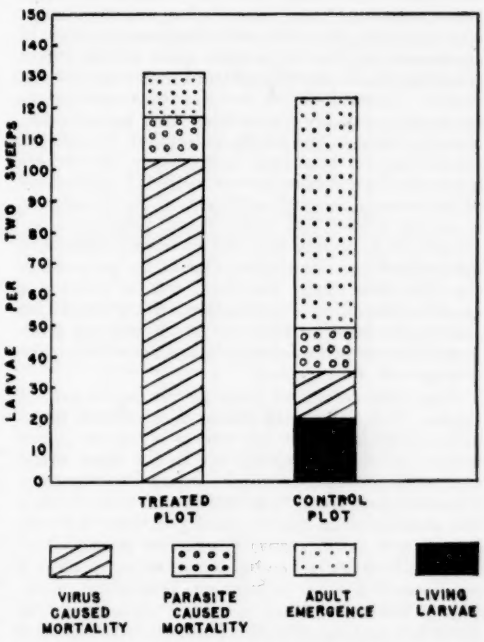

FIG. 2.—Factors responsible for decrease in the larval population to the points existing 13 days after virus application. 1950 test No. 2.

Damage to the crop was already appearing at the time of the virus application. The majority of the *Colias* larvae were in the third and fourth instars, although many were in the fifth instar and in the pupal stage. Adult emergence was just beginning. The larval population during the thirteen-day period following virus application is shown in figure 1. Considerable damage to the alfalfa crop continued during the first four days after application. Two weeks after application the crop appeared to have completely recovered. At this time no *Colias* larvae could be found in the field. Adult emergence continued for four days after virus application after which period no adults could be reared from pupae collected in the field. In a 2-acre control plot in the same field which was left untreated, the crop was almost completely destroyed and most of the *Colias* population emerged as adult butterflies. The factors affecting the populations of the treated and control plots are compared in figure 2. This graph demonstates the fact that the artificial dissemination the virus was responsible for most of the mortality in the treated field and resulted in economic control of the insect pest.

While earlier tests indicated that epizootics can be dependably produced by artificial dissemination of the virus, timing of the application proved to be a very critical factor if control of the insect were to be obtained before serious damage occurs to the crop. Allowance must always be made for the 4- to 6-day period following application during which the caterpillars will continue to feed. The length of the incubation period has proved to be largely dependent upon the daily temperatures—the disease progressing more rapidly at higher temperatures. Another important factor in timing of application is the size, or the potential size, of the population of the caterpillar. The larger the insect population, the shorter the time that elapses before serious damage occurs to the crop. It is advantageous to withhold application of the virus until most of the insect population is in second and third instar so that the degree of parasitization by *Apanteles medicaginis* Muesebeck can be determined. This parasite frequently controls the alfalfa caterpillar to such an extent that no treatment is necessary. Earlier experiments have shown, however, that if application of the virus is delayed until most of the population is in the second and third instar, fields with extremely high populations will be almost defoliated before the virus takes effect. One of the purposes of the 1950 field tests, therefore, was to develop a guide to the timing of application, with a population scale indicating time that can be allowed any given population or potential population before economic damage can be expected.

From the results of tests so far performed, it appears that fields with potential maximum populations of 50 larvae per two sweeps of the net can be treated when the majority are in the third instar and still prevent economic injury to the crop. Populations of from 50 to 100 can be treated when the population is about equally divided between second and third instar. Population potentials of 100 to 150 must be treated when the population is mostly second instar or younger. Population potentials of 150 to 200 must be treated while the larvae are in first and second instar. Population potentials of 200 and higher should be treated soon after the first first-instar larvae have appeared and while most are still in the egg stage.

The virus material used in the field tests was obtained by collecting larvae dead and dying of polyhedrosis in the field. These insects were then ground into a homogenous semiliquid state in a Waring blendor and stored until needed. In 1948, unpurified virus material was stored under various conditions in glass jars. Some was stored in an open shed. Another lot was stored in a refrigerator at +2° C. One lot was stored in a deep freeze refrigerator at −30° C. Still another sample was quick frozen in dry ice and alcohol and then stored at −30° C.

In 1950, these samples, which had been stored for 2 years, were tested in the field, in comparison with fresh virus material. In none of the samples was any loss of virulence detected. It would appear, therefore, that the primary advantage of freezing the material for storage is the prevention of the action of putrefying bacteria and resulting foul odors.

SUMMARY.—Artificial application of the polyhedral virus infecting the alfalfa caterpillar can be depended upon to produce close to 100 per cent mortality in field populations of the caterpillar when properly applied. Unless the application is correctly timed, however, excessive damage or almost complete loss of the crop may occur before the disease passes through its incubation period and destroys the insect population. A tentative guide for application is given based on potential population maximums.

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Laboratory Rearing of Grape Berry Moth[1]

E. F. TASCHENBERG, *New York State Agricultural Experiment Station, Geneva*

The literature gives no reference of grape berry moth, *Polychrosis viteana* Clemens, having been reared under laboratory or controlled conditions in the winter. The primary purpose of the investigation reported here was to develop a technique for rearing large numbers of the grape berry moth for toxicological and life history studies. Details of the methods developed follow.

Infested grape clusters were picked prior to the time that the more nearly mature larvae were leaving the berries to prepare cocoons for hibernation. Usually this collection was made during the first week of September. The clusters were distributed in layers from 3 to 4 inches deep on wooden trays having bottoms constructed of three-eighths inch hardware cloth. Although many of the larvae were not full grown, sufficient numbers of uninjured berries were present to enable the larvae to reach maturity. Tender, green grape leaves were scattered over the grapes in each tray to serve as material for the construction of cocoons. The trays, after being prepared as just described, were stacked. After the larvae had left the infested clusters and

[1] Journal Paper No. 849, New York State Agricultural Experiment Station, Geneva, N. Y., January 10, 1951.

pupated, the leaves containing the cocoons were removed from the trays. The cocoons were then snipped or picked from the leaves to facilitate handling and stored in a cold room at a temperature of 34° F. until needed.

EMERGENCE AND OVIPOSITION.—A combined oviposition-emergence cage was used when eggs were to be collected on grape berries. The oviposition compartment was a wooden frame with two vertically sliding doors in the center of one side. There were two longitudinal strips of wood across the top from which were suspended portions of grape clusters. The top, ends and sides were covered with unbleached muslin. This compartment was supported by the emergence section (bottom half) of the cage which had wooden sides and the ends were fitted with horizontally sliding doors. The bottom of the emergence section, also of wood, had a ventilation opening at each end. These ventilators were covered with screen wire and dark cloth. Running lengthwise across the middle of the compartment was a slatted shelf used to support some of the emergence trays. Above this, flush with the ends of the cage, were 8 inch wide ledges forming part of the bottom of the oviposition compartment upon which the feeding bottles were placed. Use of the emergence-oviposition cage made it unnecessary to collect and transfer the moths.

Food and water in the form of honey water were made available to the adults. At times the moths congregated on wicks placed in the honey water but it was not definitely determined that this food and water were essential.

The cage was kept in a greenhouse where the temperature varied from 65 to 85° F. Special effort was made to maintain a temperature of about 80° F. from 5 to 7 p.m., since most of the eggs were deposited at this time. The gravel floor of the room was thoroughly wetted three times daily to maintain a moderate to high humidity.

Lots of from 1200 to 1500 pupae were placed in the cage at weekly intervals; lots introduced during the previous weeks were not removed. The pupae were spread out in a shallow wooden box-emergence tray partially filled with sand moistened before being placed in the emergence compartment of the cage. These trays were moistened every other day.

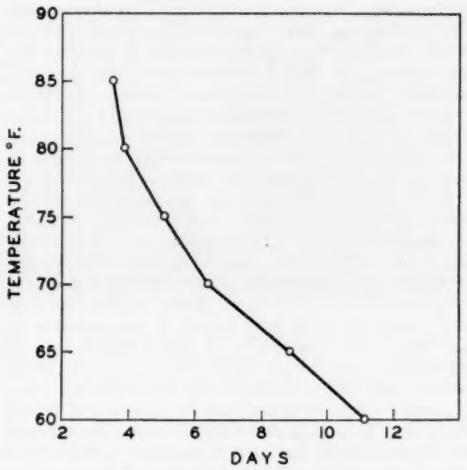

FIG. 1.—Graphic presentation of table 1 data.

The first lot of cocoons was usually placed in the cage during the last week of December. By beginning at this time it was possible to maintain a continuous population of from 400 to 500 adults by the middle of February.

OVIPOSITION.—An attempt was made to induce moths of the grape berry moth to lay their eggs on waxed paper using techniques similar to those employed successfully in the case of codling moth and oriental fruit moth. The cage used in this study was a wooden frame 20 by 14 by 14 inches, and covered on three sides and on the ends with black cloth. The other side was fitted with a pane of glass in such a manner that the sheet of wax paper could be drawn over the inner surface.

In a period of 9 days, 109 eggs were deposited on wax paper when a population level of approxi-

Table 1.—Incubation period of eggs of grape berry moth at various temperatures.

TEMPERATURES DEGREES F.		NO. OF EGGS	DAYS OF INCUBATION			DAILY DECREASE OF INCUBATION PERIOD FOR INCREASE OF ONE DEGREE IN TEMP.
			Maximum	Minimum	Average	
Constant						
60		16	12	9	11.1	
						0.44
65		13	10	8	8.9	
						0.50
70		93	7	5	6.4	
						0.28
75		4	—	—	5.0	
						0.22
80		70	5	3.5	3.9	
						0.10
85		50	4	3.0	3.4	
Intermittent						
12 hours	12 hours					
60	75	41	7	6	6.9	
60	85	28	9	5	5.8	

mately 100 adults was maintained. This observation shows that the berry moth will oviposit on wax paper and warrants further study. A greater egg deposition rate would be desirable than that obtained in this trial for laboratory studies. However, such a method of obtaining eggs would have definite advantages for certain laboratory investigation. Eggs deposited on grape berries were used in most of the insecticide tests conducted.

Since neither green nor ripe Concord grapes—the variety commonly grown locally—were available for these studies during the winter, an attempt was made to store green fruit. The green fruit was picked at the time berries were touching and was held in a 34° F. cold room. These clusters molded and were discarded long before it was possible to use them. The possibility of using stored ripe or green fruit of this or similar varieties is questionable because the berries undoubtedly would shrivel when exposed to high temperatures for a period of 6 to 8 days. In this condition the surface of the fruit would be unsatisfactory for ovicidal studies and furthermore many of the eggs would be lost or destroyed as a result of the shrinking process.

It was finally found that the varieties of Vinifera grapes such as Malaga, Tokay, Emperor and Gros Ribier purchased in local fruit and grocery stores were satisfactory ovipositon media. These fruits remained turgid after being held at relatively high temperature for 6 days or longer which was of sufficient duration for the purposes of the study. Each cluster of these grapes was divided into portions bearing from 8 to 15 berries. These were made available to moths for oviposition after first being dipped in acetone to remove any traces of possible insecticidal and fungicidal residues which may be harmful or act as a repellant to the moths, then washed in water and allowed to dry. About 4 P.M. each day these clusters were suspended in the oviposition compartment of the cage and they were removed about 9 P.M.

INCUBATION.—After the clusters of grapes bearing eggs were removed from the oviposition cage where they had been exposed for a period of about 5 hours, individual berries were then taken from the cluster, pinned to pieces of balsa wood and placed in constant temperature cabinets. Groups of eggs were permitted to hatch at each of the following temperatures: 60°, 65°, 70°, 75°, 80° and 85° F. Eggs were also exposed for 12 hour periods alternating between 60° and 70°, and 60° and 85° F. Observations on hatching were made every 12 hours under a binocular microscope. The egg shells of hatched eggs were always removed after the examination. The incubation periods of the eggs at various temperatures and the daily decrease per one degree of temperature are given in table 1. The number of days required for hatching is plotted against temperature and is shown in figure 1.

SUMMARY.—A procedure is given for rearing grape berry moth larvae to the pupal stage. An attempt to use wax paper as an oviposition media was not too successful. Moths oviposited freely upon varieties of Vinifera grapes such as Malaga, Tokay, Emperor and Gros Ribier.

Eggs were incubated at constant temperatures of 60°, 65°, 70°, 75°, 80° and 85° F. The period of incubation averaged 11.1, 6.4 and 3.9 days respectively at 60°, 70° and 80° F.

New Aphid Vectors of Strawberry Viruses

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The common strawberry aphid, *Capitophorus fragaefolii* Ckll., a species probably identical with the English species *Pentatrichopus fragariae* Theob., is the only insect with one exception to have been demonstrated to transmit a virus of strawberry. The single exception is a very closely related or synonymous species, *Pentatrichopus tetrahodus* Walk., which was reported by Whitehead & Wood (1941) to transmit crinkle under experimental conditions.

Whitehead & Wood (1945) tested seven other species of aphids recorded on strawberries in North Wales and concluded that the strawberry aphid is the only species recorded on cultivated strawberry that is implicated in the degeneration of strawberries in North Wales.

Harris (1947), working in England, considers that the strawberry aphid is probably the sole natural vector of strawberry viruses.

In conjunction with an investigation of the strawberry virus complex in California eight species of aphids other than the strawberry aphid have been tested for their ability to transmit strawberry viruses.[1] The results of the tests, presented in table 1, show that five of the eight species transmitted virus. Of the five transmitting species, two, *Myzaphis rosarum* (Walk.) and *Myzus porosus* Sanderson were found only on cultivated rose while three species, *Amphorophora rubi* (Kalt.), *Macrosiphum pelargonii* (Kalt.), and *Myzus ornatus* (Laing) were collected on *Fragaria* spp. The three species which failed in these tests to transmit virus, *Aphis forbesii* Weed, *Macrosiphum solanifolii* (Ashmead), and *Myzus solani* (Kalt.), were all collected on *Fragaria* spp.

The virus source plants used were quite varied and included naturally diseased plants of commercial varieties infected with unknown viruses, or leaves therefrom naturally infested with aphids, and experimentally infected test plants. The test plants included three wild species of *Fragaria: F. bracteata* Heller, *F. vesca* L., and a runnerless strain of an Alpine variety of *F. vesca* which are routinely used as strawberry virus indicator plants (Frazier 1951). Among the tests of the different species of aphids the acquisition feeding period on the inoculum plants ranged from four hours to seven days while the test period on the indicator plants ranged from four hours to eleven days.

The viruses transmitted were all of the relatively non-persistent type and the symptoms produced on the indicator plants were largely of the crinkle variety. They are yet to be identified or described. No transmissions of persistent virus occurred. However, few of the tests combined sufficiently long feeding periods on both reliable inoculum plants and test plants to fulfill the requirements necessary for the transmission of the known persistent type viruses of strawberry. All viruses transmitted have been retransmitted to further indicator plants by the strawberry aphid.

There is preliminary evidence of a certain degree of specificity between some of the species of demonstrated vectors and the particular viruses they transmitted which may thus afford a valuable method of isolating those viruses.

[1] The author is grateful to E. O. Essig who determined the species of aphids.

Table 1.—Tests of strawberry virus transmission with eight species of aphids from various sources of virus to wild *Fragaria* indicator plants.

SPECIES OF APHID	NUMBER OF VIRUS SOURCES	NUMBER OF APHIDS PER TEST	RESULTS OF TESTS[1]
Aphis forbesii	3	10	0/6
Amphorophora rubi	14	5–15	10/61
Myzaphis rosarum	6	12	11/30
Macrosiphum pelargonii	21	5–20	16/97
Macrosiphum solanifolii	10	10–15	0/48
Myzus ornatus	41	1–25	36/193
Myzus porosus	6	15	12/27
My us solani	2	10–15	0/6

[1] The numerator is the number of plants infected; the denominator is the number of plants inoculated.

None of the five species of aphids reported here to be vectors appeared to be as efficient in transmitting strawberry virus as is the strawberry aphid. Whether they or other untested species may be a factor in the spread of virus in the field has not been investigated but the possibility would perhaps be worth considering in any program of strawberry virus control.

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Mortality of Aphids and European Corn Borers Feeding on Corn Plants Grown in Soil Treated with Bis(2-(2-fluoroethoxy)ethoxy)methane

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Investigations on the toxic or repellent action against the European corn borer, *Pyrausta nubilalis* (Hbn.), of corn plants grown in soil treated with certain chemicals, as reported by Questel, *et al.* (1949), led to experiments in 1949 with bis(2-(2-fluoroethoxy)ethoxy)methane obtained through the courtesy of W. R. Kirner[1] of the National Research Council. This compound has the following chemical formula and properties:

$$O \cdot CH_2 \cdot CH_2 \cdot O \cdot CH_2 \cdot CH_2F$$ b.p. 14°/13 mm., Miscible with water

$$CH_2$$
$$O \cdot CH_2 \cdot CH_2 \cdot O \cdot CH_2 \cdot CH_2F$$ 120°/3 mm.

This paper reports the effectiveness of the compound in killing aphids and young corn borer larvae infesting plants grown in soil treated with it. These investigations were carried on in Toledo, Ohio, in 1949. Further information is needed, however, on minimum effective dosages, on the length of time plants grown in treated soil retain their toxicity to insects and warm-blooded animals, and on the toxicity of the material to plants and warm blooded animals.

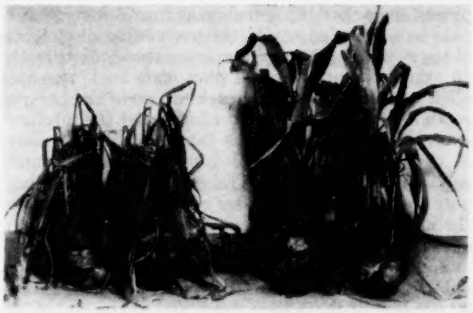

FIG. 1.—*A*, Corn growing in untreated soil—heavy damage—many living borers; and *B*, corn growing in treated soil—no living borers.

This fluoro compound would be expected to break down ultimately to fluoroacetic acid or its salts (*i.e.*, the dangerous poison "1080"). The findings of David (1950) with respect to sodium fluoroacetate put a new aspect on the use of organic fluorine compounds as systemic poisons.

Pioneer work was done by G. Schrader, a German entomologist, during the war years, as reported by Martin & Shaw (1946, pp. 37–39). He discovered bis(2-(2-fluoroethoxy)ethoxy)methane to be outstandingly active as a chemotherapeutic agent for living plants. His colleague, Kükenthal, showed that living plants absorbed, through their roots as well as through their leaves, the active compound which protected the plant from all suctorial insects for 3 to 4 weeks. Many experiments were conducted to confirm this fact. Young corn plants in a greenhouse received three waterings of a 0.1-per cent aqueous solution at the roots at intervals of three days. Eight days after the last watering the plants were cut above soil level and fed to rabbits. The rabbits ate the plants readily, but died within 24 hours. Caterpillars and aphids died a short time after being placed on plants that had been watered at the roots 8 to 10 days before with this solution.

Schrader undertook the control of phylloxera in vineyards in Germany by treating the vines at the roots. Deep holes were made with an iron pole near each vine, the holes were filled with a 0.1-per cent solution of the material and again closed with earth. After 4 weeks, in comparison with control plots, about 80 per cent of the phylloxera in the treated plots were killed. Controls of 90 to 95 per cent were obtained in trials repeated one year later.

According to Martin & Shaw "Its relatively high toxicity requires that care be taken to avoid danger to man and the unintentional poisoning of useful animals."

Preliminary experiments conducted by S. H. Bennett (1949) indicated that similar compounds acted in varying degrees as fumigants, contact and stomach poisons, and repellents.

In the present investigations with this methylal of fluoroethyl ethyl alcohol, a heavy infestation of aphids, *Aphis maidis* (Fitch), was placed on corn

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plants 10 inches tall growing in four 5-inch flower pots in a greenhouse. On the succeeding day, 1 cc. of bis(2-(2-fluoroethoxy)ethoxy)methane mixed with 20 grams of finely ground phosphate rock was applied to the soil surface of each of two of the pots, a small amount of water was added, and the mixture covered with soil. Care was taken to see that none of the mixture was applied to the above-ground portions of the plants. The soil in the remaining pots was treated with water only. On a plant basis the application to the treated pots was at the rate of about 6 pounds of toxic ingredient per acre.

Four hours after the soil was treated many aphids had dropped from the plants, 20 hours later 90 per cent of them were dead, and at the end of 72 hours all were dead. At the same time aphids on the plants growing in untreated soil were alive and healthy. Normal reproduction had continued on infested plants growing in other parts of the greenhouse.

The treated plants were grown uncaged in the greenhouse close to the untreated ones. Leaves of the untreated intermingled in some cases with those of the treated plants, but no toxic action against the aphids on any of the untreated plants was noted from this close association. It was apparent that the toxic action of the chemical was caused by translocation rather than by fumigation.

In ten other 5-inch pots in which 14-inch corn plants were growing, 0.25 cc. (about 1.5 pounds per acre) of bis(2-(2-fluoroethoxy)ethoxy)methane was poured on the soil of each and some water was added to carry the compound down to the roots of the plants.

Beginning on the fourth day after treatment leaf sections from the plants in the treated pots were rolled into small coils and each inserted into a test tube containing one or more European corn borer egg masses in the black-head state. A cotton-filled cloth-plug stopper was used to fill the mouth of the tube. After a test period of 48 hours the leaves were removed, and the number of dead and living larvae and the amount of feeding were recorded. Leaf sections from all parts of the plant were taken almost daily up to the eighteenth day after treatment. One hundred per cent mortality of the young corn borer larvae resulted in all of these tests.

In another test a heavy infestation of newly hatched European corn borer larvae was placed on 12-inch corn plants growing 5 to 8 per pot in ten 5-inch pots. Three days later the soil in each of 4 pots was treated with 0.25 cc. of bis(2-(2-fluoroethoxy)ethoxy)methane in 25 cc. of water. Five days after treatment only dead larvae were observed on the plants in the treated pots or in five of the plants that were dissected. At the same time numerous living larvae were feeding and crawling on the plants growing in the untreated pots. Seven days after treatment the corn plants in the treated pots were showing new growth in the whorls, free from borer injury, and dissection of additional corn plants from these pots produced no living larvae. By that time all the plants in the untreated pots showed severe borer injury and individual plants were infested with as many as 44 borers.

A slight burning effect on the edges of the corn leaves resulted from the application of the compound to the soil at the rate of 0.25 cc. per 5-inch flower pot. Corn plants receiving a dosage of 1 cc. to the soil per 5-inch flower pot were rather severely injured. The plants were stunted and many leaves were destroyed.

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Damage to Household Goods by the Fan Palm Caterpillar

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The fan palm caterpillar, *Litoprosopus coachellae* Hill,[1] occasionally damages rugs, drapes, and other household fabrics while getting material to make its cocoon. The pile on a rug or drape may be entirely removed in large patches. Even such short pile as that on velvet may be removed. Thin cloth or paper may also be torn up to make cocoon material. The fiber is cemented together into what are frequently very colorful cocoons. Damage to expensive robes has been observed in a shop in Riverside. Rugs and drapes damaged have often been of the most valuable kinds. Normally, the cocoon is made of the tough fiber at the base of palm trees.

The caterpillars feed on the flowers, flower shoots, and to some extent the fruit of the fan palms (*Washingtonia filifera* Wendl. and *W. robusta* Wendl.), which are common ornamental trees in southern California and Arizona. There is no evidence of feeding on leaves. Since the feeding and moving about usually occur at night, the caterpillars are rarely observed.

They most commonly enter buildings when large numbers of mature individuals are blown from trees by wind. However, a certain number fall or travel to the ground regardless of wind conditions. In one instance, hundreds of caterpillars fell to the ground near the back door of a house during a storm, and many entered the building. When on the ground, the caterpillars appear to be attracted to lights, so they are likely to enter buildings before finding a suitable place to pupate.

These fan palms bloom from April to October, and caterpillars have been observed from June 15 to October 15, 1944 in Phoenix, Arizona, and until November 1, 1950 in Riverside, California. They occur most commonly from July to September. The caterpillars taken at Phoenix on June 15, 1944 were in the third instar. In the same locality adults were collected on April 25 and August 29, 1944. At Riverside, P. H. Timberlake has taken adults at lights as early as July 25 (1933) and as late as October 6 (1948). Distribution includes Palm Springs, Los Angeles, and Riverside, California, and Phoenix, Arizona.

[1] Phalaenidae.

The caterpillar of this moth is the size of an ordinary cutworm and is usually pinkish brown in color. The adult is light tan with a pair of small, black-bordered white spots on each hind wing. The eggs are laid in groups of 25 to 40 and covered with a rough, silk-like material. The original material was determined by Mr. Carl Heinrick of the U. S. Bureau of Entomology and Plant Quarantine.

The caterpillars can be readily destroyed in the palm tree by application of DDT to the crown of the tree in June or July. They can also be killed by application of stomach poison to the flowering shoots. Removal of the flowering shoots early in the season may be equally effective.

Lighted doors near infested palm trees should be closed tightly at night to prevent access of the caterpillars. The caterpillars are relatively large, so weather stripping will usually keep out these and other pests.

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Comparative Toxicity of Tetraethyl Dithiopyrophosphate, Tetraisopropyl Pyrophosphate, and Parathion

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Preliminary laboratory tests with tetraethyl dithiopyrophosphate and tetraisopropyl pyrophosphate indicated that both these compounds were highly toxic to insects, although the latter appeared to be considerably the less toxic. Further study was then made to compare the effectiveness with parathion, another phosphorus compound now used extensively as an insecticide but also toxic to man and animals.

Tetraethyl dithiopyrophosphate is a yellow to colorless oil, slightly soluble in water and lime-stable which has been found by Ball & Allen (1949) to compare favorably as an insecticide with tetraethyl pyrophosphate.

Table 2.—Comparative toxicity of parathion, tetraethyl dithiopyrophosphate, and tetraisopropyl pyrophosphate to pea aphid adults. [5 replicates.]

INSECTICIDE	CONCENTRATION	MORTALITY IN 24 HOURS
	Parts per million (v/v)	*Per Cent*
Parathion	0.5	71
	.25	53
	.125	30
Tetraethyl dithiopyrophosphate	2.0	67
	1.0	41
	.5	36
Tetraisopropyl pyrophosphate	50.0	71
	25.0	32
	12.5	24

Tetraisopropyl pyrophosphate is a water-white liquid, only about one-tenth as toxic to white mice as tetraethyl pyrophosphate, and can be used to formulate dusts of much greater stability, inasmuch as it hydrolyzes only about one-fiftieth as fast.

Parathion is the accepted common name for 0,0-diethyl 0-*p*-nitrophenyl thiophosphate. It is much more stable than tetraethyl pyrophosphate.

Some properties of these compounds have been reported by Hall (1950).

The comparisons in this paper are based on dipping tests against the citrus red mite, *Paratetranychus citri* (McG.), and the pea aphid, *Macrosiphum pisi* (Kltb.), and on dust and spray tests against the alder flea bettle, *Altica ambiens* (Lec.), the armyworm, *Cirphis unipuncta* (Haw.), the large milkweed bug *Oncopeltus fasciatus* (Dall.), and the two-spotted spider mite, *Tetranychus bimaculatus* (Harvey).

Because of the low solubility of these phosphates in water, a 10 to 90 mixture of acetone and water was used in making up the sprays and dips with 1 per cent of saponin added as a wetting agent. Fuller's earth was used as a diluent for the dusts.

Table 1.—Comparative toxicity of parathion, tetraethyl dithiopyrophosphate, and tetraisopropyl pyrophosphate to different stages of the citrus red mite.

INSECTICIDE	TESTS WITH NYMPHS AND ADULTS (4 OR 5 REPLICATES)		TESTS WITH EGGS (8 REPLICATES)	
	Concentration of Insecticide	Mortality in 24 Hours	Concentration of Insecticide	Mortality in 7 Days
	Parts per Million (v/v)	*Per Cent*	*Parts per Million (v/v)*	*Per Cent*
Parathion	0.5	84	125.0	70
	.25	63	62.5	48
	.1	33	31.25	35
Tetraethyl dithiopyrophosphate	1.0	93	62.5	64
	.5	62	31.25	47
	.25	32	15.6	39
Tetraisopropyl pyrophosphate	5.0	83	2500.0	65
	2.5	53	1250.0	55
	1.0	21	500.0	36

Table 3.—Comparative toxicity of dusts and sprays containing parathion, tetraethyl dithiopyrophosphate, and tetraisopropyl pyrophosphate to various insects.

Insecticide	Concentration		Insect	Mortality in 2 Days	
	Dusts	Sprays		Dusts	Sprays
	Micrograms per Square Centimeter	*Parts per Million (v/v)*		*Per Cent*	*Per Cent*
Parathion	0.16	—	Alder flea beetle	96	—
	.10	50	Army worm	100	100
	.28	10	Large milkweed bug	70	100
	.058	5	Two-spotted spider mite	87	96
Tetraethyl dithiopyrophosphate	2.15	—	Alder flea beetle	42	—
	2.32	50	Armyworm	100	46
	2.15	10	Large milkweed bug	70	65
	2.50	10	Two-spotted spider mite	100	96
Tetraisopropyl pyrophosphate	2.80	—	Alder flea beetle	21	—
	3.00	500	Armyworm	13	88
	3.10	50	Large milkweed bug	30	90
	2.80	10	Two-spotted spider mite	14	87

Tests Against Citrus Red Mite.—Preliminary tests were made against the citrus red mite to determine the concentrations necessary to kill roughly 25, 55, and 85 per cent of the active stages of the mites. Replicated tests were then made with these concentrations. Mortality was determined approximately 24 hours after treatment. The results of these tests are given in table 1. When the data were plotted on log-probit paper, it was found that the median lethal concentration (parts per million) was 0.167 for parathion, 0.370 for tetraethyl dithiopyrophosphate, and 2.18 for tetraisopropyl pyrophosphate.

To find the toxicity to eggs, uninfested oranges were exposed to citrus red mite adults for oviposition in order that eggs of the same age might be available for testing. Mortality counts were made 8 days after the dipping treatment. The median lethal concentration (parts per million) was 3.125 for tetraethyl dithiopyrophosphate, 62.5 for parathion, and 940 for tetraisopropyl pyrophosphate.

Tests Against Pea Aphid.—Adult pea aphids reared on Windsor bean plants were treated by clipping leaves from the plants and dipping them in the insecticide solutions. The treated aphids were then placed on potted bean plants and kept in covered battery jars for 24 hours. The data are given in table 2. When the data were plotted on log-probit paper, the median lethal concentration was found to be 0.24 parts per million for parathion, 1.28 for tetraethyl dithiopyrophosphate, and 32 for tetraisopropyl pyrophosphate.

Tests Against Other Insects.—In the tests against the alder flea beetle and the armyworm, sprays or dusts were applied to both surfaces of infested foliage, and in the tests against the large milkweed bug and the two-spotted spider mite they were applied directly on the insects. The dusts were applied in a settling chamber, and the amount of deposit was determined by weighing an aluminum plate dusted at the same time. The data on actual insecticide deposit, shown in table 3, were calculated from these figures. Sprays were applied by means of a DeVilbiss-type atomizer. The tests against these insects were not replicated.

Mortality counts were made after 2 days. The results are shown in table 3. In tests against the alder flea beetle tetraethyl dithiopyrophosphate and tetraisopropyl pyrophosphate at respective concentrations 134 and 175 times that of parathion resulted in less than half as much kill. In the armyworm tests, although parathion gave 100 per cent kill even at the low concentration used, it was obviously much more toxic than tetraethyl dithiopyrophosphate and still more toxic than tetraisopropyl pyrophosphate. Against the milkweed bug, also, parathion was the most toxic, tetraethyl dithiopyrophosphate was next in order, and tetraisopropyl was the least toxic. In spray tests against the two-spotted spider mite 50 times as much tetraethyl dithiopyrophosphate as parathion was required to kill 96 per cent of the mites. When applied in dust form the superiority of parathion was even more pronounced.

Effect on Green Foliage.—Water suspension containing 0.2 per cent of parathion, tetraethyl dithiopyrophosphate, or tetraisopropyl pyrophosphate with 1 per cent of saponin were tested on the following young plants growing under field conditions: bean (*Phaseolus vulgaris*), beet (*Beta vulgaris*), corn (*Zea mays*), cucumber (*Cucumis sativus*), kale (*Brassica oleracea*), pepper (*Capsicum grossum*), and tomato *Lycopersicon esculentum*). Two plants of each kind were sprayed twice, 7 days apart, with a hand sprayer. No injury was observed on any of the plants 7 days after the second treatment.

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The Termite Resistance of Pinosylvin[1] and Other New Insecticides

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The natural resistance to termite attack of some woods has long been known, but chemical analyses, to determine the specific chemical constituents responsible, have rarely been made. Until very recently almost the only exception seems to have been in the case of East Indian teak, *Tectona grandis* L. The well-known resistance to weathering, decay and insect attack of teakwood is apparently due to the presence of beta-methylanthraquinone (tectoquinone). A 10 minute submersion in a 1 per cent solution of tectoquinone in acetone will indefinitely protect susceptible woods against attack by the West Indian dry-wood termite, *Cryptotermes brevis* Walker, (Wolcott 1946). The partly-eaten keys of a piano (of which one key had already been replaced with a duplicate made of mahogany), heavily infested with these termites, have thus been successfully protected against further injury, despite the fact that the untreated remainder of the piano is falling to pieces, so rapidly is its oak case being devoured.

In the East Indies, tectoquinone is extracted from teakwood waste, and in the United States is synthesized by Eastman, but in neither case is cost of production sufficiently low that this chemical can be recommended for extensive commercial adoption. Tests of many other quinones and related compounds have indicated none that is even as effective in protection against termite attack as is this natural constituent of teakwood (Wolcott 1947).

Pinosylvin, has been extracted from the heartwood of Scotch pine by Dr. Holger Erdtman, in charge of the Division of Organic Chemistry, the Royal Institute of Technology, Stockholm, Sweden. It has a diphenolic structure which "suggests that pinosylvin might be the main cause of the well-known great durability of pine heartwood" (Erdtman 1949). The sample very graciously submitted for test consisted of light, silvery flakes, of a delightful piney odor for some people, odorless to others, which floated on the surface of water, but dissolved instantly in alcohol or acetone (like the first snowflakes of winter in a forest pool), and this solution could be diluted indefinitely with water without precipitation of the crystals. Using a standardized technique (Wolcott 1947), fresh samples of flamboyán, *Delonix regia* (Bojer) Raf., were submerged for 10 minutes in solutions of pinosylvin at 2, 1, 0.5, 0.2, 0.1, 0.05, 0.02 and 0.01 per cent on July 6, 1950. The next day, the sample impregnated with 0.01 per cent pinosylvin was placed with fresh termites in a petri dish with similar samples of flamboyán treated with other chemicals. On the following morning half of the termites were on the pinosylvin sample, but by the following day all termites were dead or immobilized. For 2 months, no termites have been able to live longer than 2 or 3 days in the petri dish containing this sample.

Some inorganic chemicals, notably red mercuric iodide (Wolcott 1943), are initially very toxic to termites, but wood impregnated with them rapidly ceases to be either toxic or repellent. Many of the organic chemicals are also initially toxic, most notably zinc and copper dimethydithiodicarbamate, but none at such a great dilution or for so long a time as this 0.01 per cent of pinosylvin.

Pinosylvin is not now commercially available, but a test material referred to here as E-1817[2] can be readily obtained. Its odor is not that of pine wood, but to the entomologist is remniscent of a cotton field of which the leaves are being mass devoured by *Alabama* caterpillars. It is not so instantaneously soluble as is pinosylvin, but can be dissolved in benzol or acetone, making a colorless solution for the impregnation of wood. The treated samples of flamboyán wood, even at 2 per cent, are odorless and unchanged in appearance. The 0.01 per cent sample was toxic to termites for several weeks following impregnation, and although the samples was eaten less than 3 months later, all of these termites died. Fresh termites have not enlarged this feeding-gouge, and, indeed, all have died rather than eat the wood with 0.01 per cent stilbene.

The permanence of the protection afforded against termite attack is really of more fundamental importance in judging the value of a chemical than its initial toxicity. Thus, although pinosylvin may indeed prove to be all that its early promise indicates, the nearly 7 years of proved resistance of 0.2 per cent copper pentachlorphenate, and 2 per cent pentachlorphenol and 2 per cent DDT can not be lightly dismissed when compared with the value of chemicals more recently made available. Tests are being conducted at Río Piedras, and it is hoped that they can continue, until some of the more promising of the newer chemicals have had ample time to prove their value. As compared with DDT for instance, the butyl DDT at 2 per cent impregnation was attacked in 120 days, and the fluorine DDT (DFDT) in 161 days, but at 0.05 per cent the methoxychlor, is still uneaten a year after treatment: a far better record than that of any of the other benzol-soluble compounds previously reported. Dimethyl-tetrachlor-phthalate,[3] at this concentration, has been uneaten for a year and a half, as is also the sample treated with the plant extractive Ryania. The Laurel Hill Laboratories have submitted samples of somewhat similar compounds, one of which at 0.05 per cent has not been attacked in a year and a half, while others of the series, with but slightly differing composition, are definitely inferior. Such differences in the reactions of termites (and other insects), are possibly to be expected after observing those shown to the gamma isomer of benzene hexachloride (Wolcott 1950), as compared with the lack of protective power possessed by its other isomers. The constituents of *Dilan*[4] and *Aramite*[5] show up equally well in preliminary tests. Somewhat disappointing are the records of aldrin and dieldrin, so promising at first, but ceasing to protect at 0.2 per cent of impregnation after less than 2 years.

On the basis of the results to date, certain recommendations may be made. Of the organic compounds methoxychlor is clearly superior to ordinary DDT, and being commercially available, should displace it for wood treatment. As the tests were made with solutions in benzol, it is not to be expected that suspensions or other preparations in water will be as effectve as solutions. Benzol was also used as a solvent for 1, 1-di(2-hydroxy-3, 5-dichlorphenyl) 2,2,2-trichlorethane. The solution of dimethyl-tetrachlor-phthalate in acetone could not be di-

[1] 3,5-hydroxystilbene.
[2] $C_6H_5CH:CHC_6H_5$ (Eastman No. 1817)-Stilbene or trans-stilbene.
[3] Whitemarsh laboratories.
[4] Commercial Solvents.
[5] Naugatuck Chemical Co.

Table 1.—Days after submergence 10 minutes in solution before attack by the West Indian dry-wood termite, *Cryptotermes brevis* Walker.

Dilutions	Per Cent								
	0.01	0.02	0.05	0.1	0.2	0.5	1	2	
Pinosylvin	toxic for 2 months, not definitively eaten in 5 months								
Silbene	toxic for 2 weeks, not definitively eaten in 4 months								
Ryania	204	not definitively eaten in 18 months							
Copper pentachlorphenate	27	42	108	111	uneaten nearly 7 years				
Chlordane			20	22	25	48	373	378	End
Dieldrin		201	237	377	473	uneaten 22 months			
Aldrin		289	363	415	572	uneaten 22 months			
DDT			25	27	29	35	37	uneaten 7 years	
Butyl DDT 2,2-bis (p-butylphenyl) 1,1,1-trichlorethane			49	51	79	114	119	120	End
DFDT			7	50	58	151	157	161	End
Methoxylchlor	uneaten 1 year								
Dimethyl-tetrachlorphthalate	uneaten 18 months								
1,1-di (2-hydroxy-2,5-dichlorphenyl) 2,2,2-trichlorethane			36	uneaten 9 months					
1,1-di (4-hydroxy-3,5-dichlorphenyl) 2,2,2-trichlorethane			147	192	330	454	514	End	
1,1-di (2-hydroxy-2,5-dichlorphenyl) 2,2,2-trichlorethane	uneaten 18 months								
Benzene hexachloride:									
alpha and beta			4	5	7	10	14	44	End
gamma	136	141	147	189	249	259	303	End	
2-nitro-1,1-bis (p-chloriphenyl)									
Propane			74	83	240	uneaten 10 months			
Butane			84	uneaten 10 months					
Beta-chloroethyl-beta (p. tert. butyl phenoxy) beta-methyl ethyl sulfite			27	80	240	uneaten 10 months			

luted with water without precipitation, and the acetone solution of Ryania became milky when dilution with water was attempted.

Herein lies the great advantage of copper pentachlorphenate: for, although it can not be dissolved satisfactorily in commercial denatured alcohol, under tropical conditions its solution in pure methyl alcohol, acetone or butyl cellosolve has been diluted indefinitely with water without any indication of precipitation. It would appear to be as effective against powder-post beetles as against termites, for after spraying with a 0.2 per cent solution of copper pentachlorphenate, no more powder fell from a basket from which beetles (species undetermined) had already begun to emerge.

Of all the inorganic compounds, the water soluble or the water-miscible solution of copper ammonium fluoride (Wolcott 1949) is unquestionably superior in effectiveness, and recent preparations from the Whitemarsh Laboratories, do not require the addition of ammonium hydroxide to the water of dilution to prevent the formation of the blue-grey cloudy precipitate.

With such a variety of effective chemicals for protecting wood against termite attack, it is now possible to pick and choose, selecting on the basis of cost, or on the basis of suitability for the specific use to be made of the iméregnated wood. Visual proof of the application of copper ammonium fluoride is afforded by the subsequent bluish-grey appearance of lightcolored woods, and naturally this chemical should not be used where such a change in the appearance of the wood is undesirable. The dinitro compounds stain the wood a bright yellow, a stain which is imparted to other objects in contact with the treated wood, but also an unmistakable proof of impregnation. Most of the other effective chemicals give no such visual indication, which is another way of saying that they do not stain the wood, but the proof of their effectiveness lies in the years of service to be expected from such treated woods, free from the danger of early destruction by dry-wood termites.

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Lesser Mealworm Infestation in a Brooder House

GEORGE E. GOULD and HAROLD E. MOSES,[1]
Purdue University Agricultural Experiment Station

In September 1950 the County Agent of Elkhart County, Indiana, sent in beetles of the lesser mealworm, *Alphitobius diaperinus* (Panz.) with a note that large numbers of them were present in a brooder house. In January 1951 the County Agent of Lagrange County, adjoining Elkhart County, reported large numbers of beetles and larvae in the litter of a brooder house. Since 5000 chicks out of a total of 6000 had died in this house an investigation was started to determine if insects could be the cause of the trouble.

In Indiana in recent years many poultry raisers have adopted the practice of "deep litter" as a standard procedure in the care of the brooder house. In this method the floor of the brooder house is covered to a depth of 4 to 6 inches with litter, usually ground corn cobs and then an inch or two of straw. As the litter becomes soiled, more is added on top. In the brooder house under investigation the litter was started last July. Over 6000 broilers were raised from 6600 chicks started in July. Then 3000 more were started in September on the same litter. The mortality rate of the small chicks was quite high and deaths were attributed by local authorities to coccidiosis. The third lot, again 3000 chicks, were started in late December and the death rate was again high. The owner and the feed supplier did not believe that coccidiosis or other infectious disease was the cause of the trouble, but did find the beetles and their larvae in the litter.

An inspection was made of the infested premise by one of the authors on January 10. About 1000 chicks 3 weeks old were still alive and were confined under two brooders in a corner of the brooder house. The litter under the chicks was tightly packed and slighly damp. No insects were found in the area where the chicks were confined. About 10 feet away from the fence and in the center of the brooder house, the litter was loose and the first handful picked up was a moving mass of larvae and beetles. The temperature in the unused portion of the house was about 50° F., while the outside temperature was approximately 30°. A basket of the litter was taken into the laboratory and the insects were collected from it. The method used was to place a thin layer of the litter in a heated pan and pick out the larvae and the beetles as they moved. The population averaged 88 larvae and 18 adults per quart of litter. Pupae were also found and matured 7 to 14 days later in the laboratory.

To determine the possible effect of chicks feeding upon the insects, lots of newly hatched and unfed chicks were selected and fed by hand. One lot received five beetles each, another five larvae each and a third 10 larvae each. In feeding the chicks their mouth was forced open and the insects placed well back in the throat with tweezers. Then they were placed on regular food along with the untreated chicks. A week later all were alive and thriving.

A second test was started on 7-day old chicks where the beetles or larvae were macerated and fed. In this case food was withheld for 12 hours and then one lot was fed approximately 40 crushed beetles each and another approximately 50 crushed larvae each. All chicks remained healthy.

An infestation of this beetle was reported a few years ago in a new house in Lafayette. Upon investigation it was found that crushed corn cobs had been used in insulation in the walls.

[1] Associate Entomologist and Associate Pathologist in Veterinary Science respectively.

A Comparison of Several Repellents Against Blackflies

GENE R. DEFOLIART, *Cornell University, Ithaca, N. Y.*

During the course of investigations into the biology and control of blackflies in the Adirondack Mountains, several of the standard repellents (*Repellent 6-12*, indalone, dimethyl phthalate, and *mixture 6-2-2*) as well as several new chemicals screened at the U.S.D.A. laboratory at Orlando, Florida, were tested for their effectiveness against blackflies. Adverse weather conditions and other work limited the number of tests that were satisfactorily completed, but the results are presented due to an almost complete absence in the literature of such information.

Table 1.—Results of 26 repellent tests against blackflies near Inlet, New York, during June, 1950.

Repellent	No. of Tests	Ave. Protection Time (Min.)		
		1st Bite	3rd Bite[1]	5th Bite[1]
Propyl *N,N*-diethylsuccinamate	3	342	413+(2)	416+(2)
2,2′-Thiodiethyl diacetate	3	289	391	404
Repellent 6-12	3	370	389+(1)	392+(1)
Cyclohexyl acetoacetate	2	316	371	402
Mixture 6-2-2 (6 parts dimethyl phthalate, 2 parts each of 6-12 and *indalone*)	3	284	313	322
1,5-Pentanediol dipropionate	3	268	298	318+(1)
Dimethyl phthalate	4	240	280	324+(2)
Indalone	3	238	280	323+(1)
Dimethyl ester of cis-bicyclo-[2.2.1]-5-heptene-2,3-dicarboxylic acid	2	183	265+(1)	268+(1)

[1] Numbers in parenthesis refer to the number of tests in which no 3rd or 5th bite was received.

The repellents were applied as follows: 1 cc. to forearms between wrist and elbow, and 1½ cc. to legs between knee and ankle. The testing personnel were permitted a moderate amount of movement, but for the most part, they remained quiet, sitting or standing in a restricted area. Notations were made of the first 5 bites, and each test was considered ended when the 5th bite was received. Since the first bite was often received far in advance of subsequent bites, and the 2nd, 3rd and later bites were grouped more closely together, the effective protection time of the repellents was evaluated from the time of the 3rd bite.

Three species of blackflies, *Prosimulium hirtipes* (Fries), *Simulium venustum* Say, and *S. perissum* D. & S. were abundant and biting freely throughout the tests. The biting rate varied from less than one per minute up to 10 or 15 per minute. Exposure periods varied from 354 to 518 minutes.

Propyl *N,N*-diethylsuccinamate gave the best protection, with 2,2′-thiodiethyl diacetate, *Repellent 6–12* and cyclohexyl acetoacetate next in line. The other standard repellents, indalone, dimethyl phthalate, and *Mixture 6-2-2* were inferior to *Repellent 6-12*.

Prosimulium hirtipes (Fries) was apparently repelled for a shorter time than the other species, since the first bites usually were received from it.

Influence of Temperature on Emergence of the Blueberry Maggot[1]

W. E. TOMLINSON, JR., *N. J. Cranberry & Blueberry Research Laboratory, Pemberton*

Though the blueberry maggot has been known to be a pest of cultivated blueberries in New Jersey since 1935, no accurate records of fly emergence in the state were made prior to 1946, with the exception of 1936 when Beckwith and Doehlert (1937) recorded emergence of 38 flies from their cages between June 15 and July 17.

During the years 1946 through 1950, records of blueberry fruit fly emergence in outdoor cages were kept by the author at Pemberton, N. J. Also air temperatures were recorded in a standard U. S. Weather Bureau shelter on maximum and minimum recording thermometers these same years.

With the exception of 1950, which was unusually cool throughout the spring months, fly emergence started well in advance of June 15. Maggot-infested fruit in early July pickings indicated that the first dusting date of June 30 recommended by Beckwith (1943) was too late to protect early ripening fruit in four out of five of these years.

From 1946 through 1950, timing of dust applications for the blueberry growers has been based upon our cage records of fly emergence. The correlation between first fly emergence in the laboratory cages and temperature summations has been studied in the hope of finding a reasonably accurate method of anticipating appearance of flies in the field. Such a correlation was made by Lathrop and Dirks (1944 and 1945) with apple maggot: but their method entailed special phenological observations, viz., petal fall of McIntosh apple. That such a phenological event in the development of cultivated blueberries could be used is probable, but was not attempted. It was found, however, that a reasonably accurate estimate of first fruit fly emergence in the cages could be obtained by averaging the sums of the daily mean temperature from March 1 until first fly emergence for the 5 years. A similar correlation was also found by taking the average sum of the daily mean temperature above 43 degrees from March 1 through the date of first fly emergence. (Table 1)

The emergence curve for blueberry fruit fly was studied by Lathrop & Nichols (1932) in Maine. The curve obtained by the author in New Jersey was similar except as to dates of beginning and ending of emergence.

Table 1.—Air temperature and blueberry maggot fly emergence.

Actual Date of First Emergence	Sum from Mar. 1 to First Fly	Date When Sum Was 5215°	Deviation from Actual Emergence
	DAILY MEAN TEMPERATURE		
	° *F.*		*Days*
June 7, 1946	5318.0	June 6	−1.0
June 6, 1947	4892.5	June 11	+5.0
June 8, 1948	5294.5	June 7	−1.0
June 7, 1949	5221.0	June 7	0.0
June 14, 1950	5348.5	June 12	−2.0
Average	5215.0		
	MEAN TEMPERATURE ABOVE 43° F.		
		Date When Sum Was 1083°	
June 7, 1946	1098.0	June 7	0.0
June 6, 1947	970.0	June 10	+4.0
June 8, 1948	1166.5	June 6	−2.0
June 7, 1949	1129.5	June 6	−1.0
June 14, 1950	1051.5	June 15	+1.0
Average	1083.0		

Though these methods of estimating appearance of fruit flies have been quite accurate during the seasons they have been tested, more seasons of testing are needed to check their accuracy and validity. If over a period of years they are found to be good methods, their simplicity will recommend them because they can be used by anyone with maximum and minimum recording thermometers, a piece of paper, and a pencil.

Similar records were also obtained with summations of daily mean soil temperatures at one-inch depth in the soil from which the flies emerged, but they were more variable. More expensive equipment is required to record soil temperatures than air temperatures. In addition, soil temperatures are not easily standardized from year to year because of variations in placement of the bulb in the soil and variations in the color and texture of the soil used in the emergence cages. The air temperature recording thermometers, on the other hand, can be maintained in the same location over a period of years, so that the only variable from year to year is in the air temperatures themselves.

From five years of observation, it appears that to kill ovipositing flies the first dust should be applied 14 to 16 days after initial emergence. When initial emergence is in the first 10 days of June, the first application is not necessary before 16 days after first emergence; whereas first emergence about mid-June calls for the first application 14 days after initial emergence. Two more dust applications, 10

[1] Paper of the Journal Series, New Jersey Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Department of Horticulture.

and 20 days after the first application, will provide satisfactory control from maggots through the main picking season. For the latest ripening berries, a fourth application is recommended.

SUMMARY.—Emergence cage records of blueberry maggot fly emergence from 1946 to 1950 and observations of maggot-infested fruit in early July indicated that fly emergence was normally earlier than was thought. First dusting on June 30 has been too late to protect early ripening fruit. Initial fly emergence in the cages was generally found to occur when the sum of the daily mean temperature after March 1 was 5215 degrees, or when the sum of the daily mean temperatures above 43 degrees totalled 1083 degrees. If further testing shows that these methods are accurate, their simplicity will recommend them. Soil temperatures were less useful because of more variables in addition to the need for more expensive equipment. Observation of flies emerging in outdoor cages indicated that the first dust should be applied 14 to 16 days after first emergence, according to earliness or lateness of season.

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Effect of Green Peach Aphid Damage on the Nicotine Content of Tobacco[1]

LOUIS FEINSTEIN and PATRICK J. HANNAN,
U. S. Department of Agriculture, Agricultural Research Administration, Bureau of Entomology and Plant Quarantine

The green peach aphid, *Myzus persicae* (Sulz.), has been known in the United States for many yeas as a pest of a wide variety of vegetables, fruits, and ornamental plants. In 1946 this insect attacked tobacco in certain areas in considerable numbers, and during 1947 and 1948 it reached proportions that caused much concern. The effect of this aphid attack on the nicotine content of the damaged tobacco was therefore determined.

Nicotine analyses were made on comparable samples of aphid-damaged and undamaged tobacco. These samples were obtained from fields in various locations in South Carolina and Tennessee in 1947 and 1948. The analyses for nicotine were made on air-dried materials by the Association of Official Agricultural Chemists' method. All samples were analyzed in duplicate, and the results that are given in the accompanying table are the averages of the two analyses. The duplicates agreed closely in all cases.

The aphid-damaged samples of tobacco consistently showed less nicotine than the comparable undamaged samples, although in a few instances the difference was so slight as to be within the limits of error of the analytical method.

[1] Tobacco samples were taken by N. Allen, entomologist, stationed at Florence, S. C., and L. B. Scott, entomologist, stationed at Clarksville, Tenn.

Table 1.—Nicotine content (in per cent) of tobacco undamaged and damaged by the green peach aphid.

YEAR AND SAMPLE	UNDAMAGED	DAMAGED
South Carolina—Flue-cured		
1947		
A	1.05[1]	0.82
B	1.64[2]	1.51
C	2.51	2.00
D	1.78	0.89
1948		
E	2.06	1.93
F	2.68	1.95
G	1.05	1.00
H	2.06	2.00
Tennessee—Dark-fire cured		
1947		
I	5.01	4.34
J	5.30	4.10
K	2.28	2.08
L	3.50	3.24
1948		
M	4.13	2.48
N	3.85	3.13
O	4.20	2.65
P	4.70	3.12
Q	4.54	3.49
R	4.20	2.05
Tennessee—Burley		
1948		
S	1.41	0.62

[1] Best tobacco from field where aphid damage was severe.
[2] Damaged by aphids but not severely.

Dr. J. J. Paul has resigned his position with the Wisconsin Alumni Research Foundation to accept a position as Assistant Professor of Entomology at the University of Georgia.

OBITUARIES

Percy Nicol Annand, 1898-1950

Dr. Percy N. Annand, Chief of the Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture, died March 29, 1950.

Dr. Annand's career in the Department of Agriculture began in 1929 when he was selected to participate in the solution of the sugar beet leafhopper problem, one of immense importance to western agriculture, particularly in the Great Basin area, central California, eastern Oregon, and Washington. Dr. Annand's initial work on this assignment was a study of the leafhopper in California in relation to the basic environmental factors that influence the seasonal activity of the insect. The development of profitable research along these lines required vision and an inherent desire to probe deeply into the elemental or basic features of the problem. That Dr. Annand measured up to the demands of this assignment was recognized by his being placed in charge of the sugar beet insect investigations about a year later. These investigations covered an extensive study, in the whole western area, of not only the leafhopper but also the other pests which affected the culture of sugar beets. The experience gained in directing this vast out-of-door study of an insect, as well as exacting laboratory work pertaining to the subject, gave him a keen appreciation of the difficulties involved in obtaining basic data on an insect and in the evaluation of those data in terms of practical usefulness. Furthermore, the assignment involved the direction of a staff of young entomologists and cooperation with state and other federal officials, some of whom were engaged in crop culture problems affected by the insect and others in forestry and grazing land projects. Since some of the phases of these investigations involved the development of special techniques and the recording of a succession of desert host plants of the leafhopper and desert climatological factors, mention of the following entomologists who contributed to these new studies under Dr. Annand's direction seems appropriate: W. C. Cook, J. C. Chamberlin, Ford Harries, O. A. Hills, W. A. Shands, E. W. Davis, George York, V. A. Romney, H. E. Dorst, H. E. Wallace, C. E. Henderson, and Robert A. Fulton. Because of this background of research and experience in the direction of a large staff of workers, he was transferred to Washington, D. C., to assist the Division Leader in the administration of the work conducted by the Bureau under the Division of Truck Crop and Garden Insect Investigations: the sugar beet insect investigations being a project of that Division.

After serving in this capacity for about a year, Dr. Annand was elevated to the position of Division Leader to direct investigations of insects affecting cereal and forage crops, including stored grain and mill pests. During this tenure of office (1934–1937) a grasshopper outbreak menaced several of the western states and the Congress of the United States authorized and made available funds to implement, in cooperation with the affected states, the first large-scale grasshopper control campaign carried on in the United States. Dr. Annand was not only responsible for the results of the research on grasshoppers vital to the successful application of methods to prevent crop destruction, but he also directed the large-scale baiting and other control operations.

In 1937 he was made coordinator of all research work of the Bureau and in 1939 he became Assistant Chief of the Bureau in charge of research work. In that capacity he gave counsel and guidance on all research programs of the Bureau, including those which were basic to the successful conduct of control campaigns against grasshoppers. phony peach disease, white-fringed beetle, Dutch elm disease, and other pests.

Following the death of Lee A. Strong in 1941, Dr. Annand was appointed Chief of the Bureau. Shortly thereafter our country became directly involved in World War II. It was during the war period that Dr. Annand's stature as an administrator and a scientist was revealed. The magnitude and complexities of the office of the Chief of Bureau increased. The ranks of the Bureau were depleted. The military establishment needed the trained specialists and others for insect control in the field of military operations which ranged from Europe to the South Pacific. And at home the entomologist was needed to help the farmer produce food to meet the wartime requirements of this country and our allies. The war also posed new problems in the field of plant quarantines. The rapid movement from area to area by airplanes needed prompt and alert attention to detect and destroy pests that were inadvertently brought in with troops or cargo, or to discover those that might be deliberately introduced by our enemies. The splendid assistance which the Bureau received from the States and industry during this period of stress was evidence of the confidence these people had in Dr. Annand's leadership. The channeling of entomological problems of the Bureau and the country to a peace-time basis required rare judgment and forbearance, and this responsibility he accepted and met advantageously. At no time had the challenge to the entomological profession been so great as during World War II and the period which followed. That this challenge was met successfully can be viewed with considerable pride by those who worked under Dr. Annand's direction and those in the States and in industry who contributed so ably. Postwar problems involved the development of new chemicals into useful insecticides, and the extensive use of airplanes for dispensing insecticides. Also, the growth in domestic and intercontinental travel, and in transportation of goods by air, created new problems in the administration of quarantines.

The Lasker Group Award for 1948 was presented to the Bureau of Entomology and Plant Quarantine by the American Public Health Association in recognition of distinguished services in the solution of problems involving the health and comfort of the Armed Forces, with particular reference to insect-borne diseases.

Dr. Annand was known to his associates in the Bureau as one who was sympathetic with, and could be depended upon to support, fundamental and basic studies on insects even if their economic aspects were not clearly or readily discernible. In the Department, Dr. Annand was recognized and highly regarded for his cooperativeness and his exceptionally broad grasp of the interrelationship of the work of the various Bureaus and the States. He was an attentive listener, a clear and forceful speaker, and

PERCY NICOL ANNAND, 1898–1950

his patience was not only appreciated by his coworkers but was a matter of comment by students at San Mateo Junior College, California, where he taught before entering the government service. His high sense of humor was often manifested by a hearty laugh.

Dr. Annand's last public appearance was before the American Association of Economic Entomologists, of which he was past President, at Tampa, Fla., December 13–16, 1949, where he presented the paper entitled "Today in Foreign Plant Quarantine." He was then not his usual self, a fact not recognized by the general audience, but to those who knew him well it was an indication of the illness which led to the death of one who had contributed unstintingly to the field of entomology and who had enriched the lives of those who had known him.

Behind the scenes of the one whose life's work has been related here was his wife, to whom we pay tribute for her sympathetic and understanding aid to her husband in the multitudinous problems imposed upon him in the course of public service.

Dr. Annand was born at Telluride, Colorado, Nov. 16, 1898. He received the degree of Bachelor of Science from Colorado State College in 1920. As an Assistant in biology at Stanford University in 1921 and 1922 he earned his Master of Arts degree. During the period when he was head of the Biology Department of San Mateo Junior College, California, he studied at Stanford University and received a Ph.D. degree in 1928. He is survived by his wife, Mrs. Ruth E. (Lovett) Annand, a daughter, Doris M., and a son, Richard J., and by two brothers, Robert N. and Dr. J. W. Annand.

P. V. CARDON
W. H. WHITE

Henry Ellsworth Ewing, 1883-1951

Dr. Henry Ellsworth Ewing, for many years a world authority in the classification of the Arachnida and, in general, of ectoparasites of man and other higher animals, died in Garfield Hospital, Washington, D. C. on January 5, 1951.

Dr. Ewing was born in Arcola, Illinois, February 11, 1883. He attended Knox College, took his bachelor's degree in the University of Illinois in 1906 and his Master's degree from the same school in 1908. He studied in the University of Chicago in 1906 and 1907 and was Schuyler fellow at Cornell during 1910 and 1911, receiving his Ph.D. degree from Cornell in 1911.

Previous to his employment in the Department of Agriculture, Bureau of Entomology, Dr. Ewing taught entomology and zoology and served as assistant entomologist, first to Iowa State College and later in the Oregon Aggricultural Experiment Station. From 1919 to 1947 Dr. Ewing studied Arachnida in the Bureau of Entomology and in the U. S. National Museum. In 1947 he became a collaborator in the Department of Agriculture Bureau of Entomology and Plant Quarantine.

During his long period of activity Dr. Ewing published many technical articles dealing largely with the arachnids which were his specialty and with external parasites of animals in general. He contributed to scientific Journals in his field and to the *Encyclopaedia Britannica* and wrote his well-known "*Manual of External Parasites*," published in 1929.

Dr. Ewing was a member of the American Association for the Advancement of Science, later a Fellow in the Association, a member of the Iowa Academy of Science, a Fellow of the Entomological Society of America, a member of the Society of Mammalogists, the Society of Parasitologists, the American Association of Economic Entomologists, the Ecological Society, the Entomological Society of Washington, the Helminthological Society of Washington and many other organizations in the field of the biological sciences.

Dr. Ewing is survived by his widow, Mrs. Riley Ewing, of Takoma Park, Washington, a son, Paul M. Ewing, and a daughter, Mrs. Lydia Frances Grover, of Los Alamos, New Mexico and by a sister and four brothers.

Dr. Ewing was buried in Rock Creek Cemetery in Washington.

NOTES

Dr. D. G. Denning, for several years past a member of the staff of the University of Wyoming Agricultural Experiment Station, has become associated with the Velsicol Corporation of Chicago. His headquarters, for the present, will remain at Laramie Wyoming where his address will be 967 North Tenth St.

Dr. Neely Turner, entomologist, at the Connecticut Agriculture Experiment Station has recently sailed for England with Dr. A. H. McIntosh of the Rothamsted Agricultural Experiment Station. Dr. Turner will conduct research on insecticides and fungicides at Rothamsted for a six-month period in exchange with that institution. Dr. McIntosh has just completed a year's study at the Connecticut station.

PROCEEDINGS OF THE TWENTY-SECOND ANNUAL MEETING

Eastern Branch, American Association of Economic Entomologists

Warwick Hotel, Philadelphia, Pennsylvania

November 20 and 21, 1950

The Twenty-Second Annual Meeting of the Eastern Branch, A.A.E.E., was gotten under way at 9:30 A.M., November 20, 1950, at the Warwick Hotel in Philadelphia, Pa. The Chairman, Mr. Edwin Gould, presided over a two-day meeting in which 42 papers were presented and discussed. On the second day of the meeting, President C. P. Clausen brought greetings from the parent association and invited all members present to attend the national meetings held in Denver during the week of December 18.

At the preliminary business meeting on November 20, the report of the Secretary-Treasurer was presented and referred to the Auditing Committee. The Chairman appointed the following committees:

Nominations: Harold Steiner, Clyde Smith, C. C. Alexander.
Auditing: M. M. Darley, Ralph E. Heal.
Resolutions: E. H. Wheeler, E. N. Cory, Donald L. Collins.

Report of the Secretary-Treasurer

Notices for the Twenty-Second Annual Meeting were sent out to approximately 800 members of the American Association of Economic Entomologists residing in the Eastern Branch territory in September. Paper titles were solicited for the meeting scheduled for November 20 and 21 at the Hotel Warwick in Philadelphia. A total of 42 paper titles were submitted which were arranged in a program covering two days. The printed program was mailed to all members in the Eastern Branch territory ten days before the meeting date. Membership and registration dues amounted to $438.00 for 1949–50.

At the final business session on Tuesday, November 21, 1950, the following regular committee reports were submitted, discussed and voted that they be accepted.

Report of the Resolutions Committee

1. Whereas, since our last meeting death has taken several of our members, namely P. N. Annand, Earl G. Brewer, Brayton Eddy, Arthur C. Mason, W. P. Yetter, Jr. and L. O. Howard, be it resolved that our sympathy and sense of loss be recorded in the minutes of this meeting.

2. Whereas, the President of the American Association of Economic Entomologists, Dr. C. P. Clausen, attended this meeting, not only as a member of our own group but to bring greetings and official messages from the Association, be it resolved that the Eastern Branch extend to him its appreciation and best wishes.

3. Whereas, the Chairman of the Eastern Branch, Mr. Edwin Gould, has ably upheld the tradition set by his predecessors in conducting a well organized and fast moving conference, be it resolved that the thanks of the Eastern Branch be extended to him.

4. Whereas, the conference of the Eastern Branch at the Hotel Warwick in Philadelphia has had fine accommodations and enjoyed quiet and unobtrusive hospitality, be it resolved that the hotel be complimented and thanked for its efforts.

5. Whereas, the arrangements for this meeting were made directly and personally by Dr. B. F. Driggers, our Secretary-Treasurer, be it resolved that the Eastern Branch extend to him its thanks; be it further resolved that this group takes this opportunity to recognize and express appreciation for Dr. Driggers' quiet and efficient services year after year as our Secretary and Treasurer.

6. Whereas, the Eastern Branch publication *Entoma* has achieved such wide recognition and acclaim for the unique position which it has come to hold among publications for entomologists, that it has been adopted by the parent association, be it resolved that the Eastern Branch herewith express its pride in *Entoma's* editor, Dr. George S. Langford, and its appreciation of the untiring efforts of Dr. Langford and the Editorial Board to develop and improve this now indispensable publication.

7. Whereas, during World War II, entomologists served in combat forces, and as entomologists so effectively that the profession is now recognized by its inclusion in military tables of organization, be it resolved that the Eastern Branch of the American Association of Economic Entomologists urge each member to complete and return without delay the questionnaire he or she will receive from the National Research Council for the purpose of the National Roster of Scientific Personnel.

8. Whereas, the Congress of the United States, charged with the duty of making laws for the protection of the public and to advance the public interest from time to time has occasion to study the laws and regulations relating to chemicals used in food production and processing, to determine whether they continue to meet the needs of our rapidly changing economic structure, and whereas, the need for various types of effective insecticides is most urgent in order to secure and maintain a high level of production of good quality food, feed, and fiber to meet domestic and world needs, be it resolved that the Eastern Branch of the American Association of Economic Entomologists believes that, on the whole, existing regulations and procedurees now being followed in the development of more effective insecticides and in the control of their use, constitute adequate protection of the health and best interests of the public.

Be it further resolved that a copy of this resolution be sent to (a) the Hon. James J. Delaney, Chairman of the Select Committee to Investigate the Use of Chemicals on Food Products, (b) the Hon. Secretary of Agriculture, (c) the Secretary of the American Association of Economic Entomologists.

Respectfully submitted,
Ellsworth H. Wheeler
E. N. Cory, D. L. Collins

FINANCIAL STATEMENT

Balance on hand, November 18, 1949		$ 3,658.43
RECEIPTS		
Dues for 1948–1949	$ 4.00	
Dues for 1949–1950—November 1949 Meeting	438.00	
Dues for 1950–1951	152.00	594.00
Receipts for *Entoma*		8,700.00
Total Receipts		$12,952.43
DISBURSEMENTS		
Stark Films—Projection Equipment	60.00	
Payment to Editor of *Entoma*—Regular	500.00	
Payment to Secretary-Treasurer 1950	200.00	
JOURNAL OF ECONOMIC ENTOMOLOGY—1944–1948 Extra Pages	1,551.59	
Expenses of Secretary-Treasurer—21st Annual Meeting	22.67	
Clerical Services		
Eastern Branch	55.70	
Entoma	206.64	
Postage and Stamped Envelopes		
Eastern Branch	66.48	
Entoma	625.00	
Printer		
Eastern Branch	34.80	
Entoma	4,994.99	
Double Payment of Dues	14.00	
Total Disbursements		8,331.87
Balance on hand, November 15, 1950		$ 4,620.56
Distributed as follows:		
Checking Account, the Union National Bank and Trust Company, Mount Holly, N. J.	$4,654.46	
Less Outstanding check: 11/13/50—Edith B. Fagan	35.90	
	$4,618.56	
Cash on hand in office	2.00	
		4,620.56

BYRLEY F. DRIGGERS
Secretary-Treasurer

REPORT OF THE AUDITING COMMITTEE

Your Auditing Committee has examined the financial statement, books and records of the Secretary-Treasurer (Dr. B. F. Driggers) and those of the Editor of *Entoma* (Dr. George S. Langford) and find them correct and in good order.

RALPH E. HEAL
MERRILL M. DARLEY

REPORT OF THE NOMINATING COMMITTEE

Your Committee proposes the following names as officers of the Eastern Branch:

For Chairman: F. H. LATHROP
For Vice-Chairman: FLOYD F. SMITH
For Secretary-Treasurer (3 years): BYRLEY F. DRIGGERS

HAROLD STEINER
CLYDE SMITH
C. C. ALEXANDER

Under the item of New Business, Dr. Albert Hartzell proposed the following resolution:

"In order to counteract adverse publicity on the use of insecticides following the spray residue hearings and congressional investigation, be it resolved, that the Eastern Branch, A.A.E.E., Chairman appoint a Committee to inform the public through the medium of the press of the benefits that result from the proper use of insecticides, fungicides and other economic poisons."

After some discussion the resolution was passed without a dissenting vote. Subsequently, Chairman Lathrop appointed a five-man committee consisting of Dr. Albert Hartzell, Dr. J. L. Horsfall, Dr. C. E. Palm, Dr. B. B. Pepper, and Dr. F. C. Bishopp, Chairman.

Adjournment followed the final Business Session.

MEMBERS AND GUESTS REGISTERED AT THE TWENTY-SECOND ANNUAL MEETING, EASTERN BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, NOVEMBER 20 AND 21, 1950

Adams, J. A.
Adams, Lloyd
Adams, Louis J.
Alexander, C. C.
Amos, J. M.
Asquith, Dean

Back, Richard C.
Badertscher, A. E.
Baerman, G. D.
Baillie, E. C.
Baker, Howard
Barker, Philip
Barthel, W. F.
Beacher, John H.
Beard, R. L.
Becker, William B.
Beed, Donald
Beinhart, E. G.
Berry, R. C.
Bishopp, F. C.
Bissell, T. L.
Blackburn, N. D.
Blauvelt, W. E.
Blodget, W. S.
Bobb, M. L.
Bodenstein William G.
Bodenstein, Otalia Frances
Bodine, E. W.
Book, R. O.
Boyd, William M.
Brandes, Gordon A.
Brann, James
Brehm, William L.
Brelsford, Arthur B.
Brewer, J. L.
Brodine, A. M.
Bromley, S. W.
Brunn, Lynn K.
Brunson, M. H.
Buettner, William O.
Buntin, George
Burbutis, Paul
Burgess, E. D.
Burnett, Douglas Jr.
Burnett, Thomas
Burrage, R. H.
Bussart, J. E.
Butler, George

Campbell, F. L.
Carlson, D. A.
Cassady, J. T.
Castillo, R. L.
Chase, Ronald R.
Chisholm, R. D.
Clausen, C. P.
Clower, D. F.
Cockran, James H.
Cohill, R. W.
Collins, Donald L.
Compton, C. C.
Condron, Carl
Connell, W. A.
Connelly, P. J.
Cook, Spencer E., Jr.
Cory, Ernest N.
Cox, J. A.
Crissman, W. I.
Cunningham, A. W.

Daniels, C. H.
Darley, M. M.
Darsie, Richard F.
Davis, Don
Dean, R. W.
Dewey, J. E.
Dickinson, B. C.
Dietz, Harry F.
Dirks, C. O.
Dobbins, T. M.
Dobrovksy, T. M.
Doehlert, C. A.
Dominick, C. B.
Dorland, Wayne E.
Doty, A. E.
Dowden, P. D.
Driggers, Byrley F.
Dutky, Samson R.
Dye, H. W.

Earhart, Gus
Eitman, L. P.
Evans, J. A.

Feichtmeir, E. F.
Feustel, William K.
Filmer, Robert S.
Fleming, W. E.
Foster, James R.
French, Carl F.
Friend, R. B.
Frost, S. W.
Fulton, R. A.

Galloway, A. L.
Gambrell, F. L.
Gast, R. T.
Geigle, W. F.
Gesell, S. G.
Gilbert, Engel
Ginsburgh, Joseph M.
Girth, Harold
Glass, E. H.
Gleissner, Bruce
Gould, Edwin
Granett, Philip
Grant, Orin B.
Grayson, J. M.
Greenwald, Margaret
Gyrisko, George

Haas, C. Y.
Hadley, C. H.
Haeussler, G. J.
Hahn, P.
Hambleton, Edson J.
Hamilton, Don
Hammer, O. H.
Hanley, Joseph F.
Hanna, R. B.
Hansens, Elsn J.
Hartley, R. O.
Hartzell, A.
Hawkins, J. H.
Hawley, I. M.
Haynes, Harry L.
Heal, Ralph E.
Henning, W. E.
Herold, Richard C.
Hill, C. H.
Horsfall, J. L.
Hovey, Charles L.
Howe, Wayne L.
Huckett, H. C.
Hutchinson, Martin T.

Incho, Mr. & Mrs. Harry

Jakob, Werner L.
Jarman, Philip
Jarnagin, W. M.
Jaynes, H. A.
Jennings, C. C.
Jobbins, D. M.
Johnson, G. A.
Johnson, J. P.
Jones, M. P.
Jordan, W. M.

Kaan, Helen W.
Karlovic, John
Kerr, T. W.
King, J. L.
Knutson, Herbert
Koblitsky, Louis
Krausche, K. K.
Kriner, R. R.
Kulash, W. M.

Langford, George S.
LaPlante, A.
Larson, N. P.
Lathrop, F. H.
Leiby, R. W.
Lembach, John V.
Leonard, M. D.
Lienk, S.
Long, John C.

MacCreary, Donald
Majure, W. J.
Malcolm, D. M.
Manzelli, M. A.
Marshall, Donald S.
Mathewson, John A.
Maughan, F. B.
Maxwell, J. M.
McAlister, L. C., Jr.
McCauley, W. E.
McGovran, E. R.
McIntosh, A. H.
McMurray, J. F.
McNess, George
Meltzer, Theodore, H.
Melvin, Roy
Menusan, H.
Merritt, J. M.
Meyer, Martin T.
Miller, A. C.
Mitlin, Norman
Morton, Donald J.
Mueller, Philip P.
Mundinger, F. G.

Nelson, F. G.

Parker, L. B.
Parr, Thaddeus
Pass, Herbert A.
Pechuman, L. L.
Pepper, Bailey B.
Pepper, J. O.
Perri, Val
Peterson, Alvah
Peterson, P. D.
Pierce, Henry F.
Pierpont, Roger
Pimentel, David
Piquett, P. G.
Poland, J. Lloyd
Poos, F. W.
Porter, Richard P.
Pyenson, Louis

Raesler, Mildred E.
Ratledge, Edw. L.
Rawlins, M. A.
Reed, L. B.
Reichard, M. D.
Rex, Edgar G.
Roark, R. C.
Rogers, George H.
Roth, Roger W.
Rowell, J. O.
Ruppenthal, A. B.
Rutschky, Charles
Rutschky, Charles

Schmidt, B. G.
Schwardt, H. H.
Schoene, W. J.
Scoggin, J. K.
Scott, H. L.
Sharp, S. S.
Spear, Philip
Shepard, Harold H.
Simpson, G. W.
Sisson, H. A. Jr.
Sloan, M. J.
Smith, Clyde F.
Smith, C. L.
Smith, J. Morris
Smith, Laurel G.
Smith, Thomas L.
Starnes, Eleanor
Starnes, Ordway
Stearns, L. A.
Steiner, Harold M.
Stevens, John E.
Stultz, H. T.
Sweetman, H. L.

Taschenberg, E. F.
Tashiro, H.
Thome, H. J.
Thompson, Hugh
Thompson, Robert
Tomlinson, W. E. Jr.
Turner, Neely

Udine, E. J.
Vance, A. M.
Vandenberg, G. D.
Van Geluwe, John
Van Winkle, D. C.
Vinzant, J. P.
Wagner, William E.
Walker, Harry G.
Wallace, Philip P.
Wallace, Robert T.
Weigel, C. A.
Welch, W. A.
West, R. W.
Westcott, C.
Wheeler, Ellsworth H.
Whitcomb, W. D.
Wilbur, D. A.
Williams, A. T.
Willis, Edwin R.
Woodbury, E. N.
Woodruff, Nancy
Zukel, John

TENTH ANNUAL MEETING, NORTHWEST VEGETABLE INSECT CONFERENCE

Imperial Hotel
Portland, Oregon
January 22, 23 and 24, 1951

The tenth annual meeting of the Northwest Vegetable Insect Conference was held at the Imperial Hotel, Portland, Oregon on January 22, 23, and 24, 1951. The conference membership is comprised of State, Federal and Dominion entomologists engaged in research or extension work on insects of vegetable and related crops in Oregon, Washington, Idaho, Montana, Utah, British Columbia and Alberta. Representatives from California and Alaska also were in attendance and made valuable contributions to the conference.

H. C. Manis was chairman and C. L. Neilson, co-chairman of the conference. January 22 and 23 were closed sessions and Janauary 24 was open to members of industry. K. M. King was discussion leader for insects attacking crucifer, carrots, lettuce, corn, celery and onions. Other discussion leaders were James R. Douglas for insects of beets, tomatoes, beans and hops; S. C. Crumb Jr. for insects of potatoes; H. E. Morrison, for soil arthropods and D. J. Crowley for insects of small fruits, berries, and ornamentals.

On the evening of January 23 a banquet was held for entomologists with H. M. Armitage as toastmaster. R. L. Webster, chairman of the Department of Entomology, State College of Washington, reviewed some of his experiences as an entomologist during the past 45 years, and L. B. Reid of the Division of Insects Affecting Truck Crops, U.S.D.A., Washington, D. C. discussed statistics in relation to entomological researchl

On the morning of January 24 the discussion leaders presented the results of the 1950 research work to members of industry at the open session which was held in the Junior Ballroom of the Multnomah Hotel.

Members of the Executive Committee for 1952 are H. S. Telford, Entomologist, State College of Washington, Pullman, Washington, Chairman; H. E. Morrison, Entomologist, Oregon State College, Corvallis, Oregon, Co-chairman and David H. Brannon, Extension Entomology Specialist, State College of Washington, Pullman, Washington, Secretary-Treasurer.

The 1952 meeting of the conference will be held on January 21, 22 and 23 at the Imperial Hotel, Portland, Oregon.

The following persons registered during the closed session:

Loren D. Anderson
V. Anderson
Harry Andison
H. M. Armitage
Don Berry
David H. Brannon
E. P. Breakey
Joseph C. Chamberlin
H. H. Crowell
D. J. Crowley
S. E. Crumb, Jr.,
John E. Davis
D. W. Dean
Morrill Delano
Chas. F. Doucette
J. E. Douglas
Paul M. Eide
Robert W. Every
Harry Fulton
C. W. Getzendaner
L. S. Getzendaner
H. H. Hessig
Chas. R. Hunt
Sid Jones
K. M. King
Louis W. King
Ted Knoblauch
G. F. Knowlton
B. J. Landis
M. C. Lane
Harold F. Madsen
H. C. Manis
Chas. H. Martin
H. E. Morrison
Don C. Mote
C. L. Neilson
Walter E. Peay
Ronald W. Portman
T. B. Reid
R. G. Rosensteil
Ralph Schopp
Wm. H. Shaw
Andrew Steiner
Lloyd L. Stitt
M. W. Stone
H. S. Telford
L. C. Terriere
Byrne F. Thrailkill
C. L. Vincent
A. J. Walz
Richard H. Washburn
R. L. Webster
Clyde B. Whittinger
J. Wilcox

K. P. EWING HONORED

K. P. Ewing, in charge of the Waco, Texas, laboratory of the Division of Cotton Insect Investigations, Bureau of Entomology and Plant Quarantine, has been selected by the *Progressive Farmer* as the "Man of the Year." This is an annual award for outstanding service to Texas agriculture. Mr. Ewing was given this distinction because of his constructive work on the control of various cotton insect pests and, in particular, the development of a community cotton insect control program. This program involved the early application of insecticides in an area where the boll weevil and thrips are a serious menace to the cotton crop every year. A marked increase in the average cotton yield resulted, during the last two seasons, in the communities where the control measures were put into effect.

CAMERON SIDDALL

The Pennsylvania Salt Manufacturing Company of Washington has named Cameron Siddall assistant sales manager for agricultural chemicals in the eleven western states it was announced from Tacoma by William J. F. Francis, Pennsalt Western Agricultural Chemicals Sales Manager.

Mr. Siddall will continue to make his headquarters in Pennsalt's district offices in the Woolsey Building, 2168 Shattuck Avenue, Berkeley, California, where he has been serving as district manager for technical service and sales of agricultural chemicals for California, Arizona and New Mexico.

Before coming to California, Mr. Siddall was manager of Pennsalt's sales and manufacturing operations at Bryan, Tex. He is a graduate of Texas Agricultural and Mechanical College, formerly was State Entomologist for the Texas Department of Agriculture, and is a past president of the Texas Entomological Society. He served in the armed forces during World War II.

PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL MEETING

The Cotton States Branch, American Association of Economic Entomologists

Peabody Hotel, Memphis, Tennessee

February 5, 6, and 7, 1951

The twenty-fifth annual meeting of the Cotton States Branch, A.A.E.E. was held in the Peabody Hotel, Memphis, Tenn. on February 5, 6, and 7, 1951. The meeting was held concurrently with the Forty-eighth Annual Meeting of the Association of Southern Agricultural Workers. As in January 1949, when joint meetings were held in Baton Rouge, Louisiana, adverse weather conditions prevailed which reduced attendance. Snow, sleet, and ice covered the highways for hundreds of miles in every direction from Memphis. Considering the unfavorable weather conditions and the fact that there were very few in attendance from Texas and Oklahoma because of the formation of the Southwestern Branch, the attendance could be considered fair. The registration reached a total of 137.

Chairman J. W. Ingram opened the meeting promptly as scheduled on the first morning, February 5, and the program schedules were maintained throughout the sessions. Chairman Ingram followed the precedent set by some of the other Branches in relinquishing the time usually given to the Presidential address in favor of the paper reading sessions.

The program for the two and one-half day meeting was not crowded. It consisted of 26 scheduled papers, interspersed with addresses by several prominent invitational speakers. The short paper-reading sessions made it possible for the audience to ask questions and indulge in a great deal of discussion from the floor. The sessions were well attended. Several people commented that this was the only meeting of its kind where they had listened to every paper that was presented.

Among the prominent speakers who brought interesting, informative, and timely messages were Roy E. Campbell, President of the Parent Association, Alhambra, Calif.; F. C. Bishopp, Assistant Chief, In Charge of Research, Bureau of Entomology and Plant Quarantine, Washington, D. C.: R. T. Yates, representing the National Agricultural Chemicals Association, Wilmington, Delaware; R. W. Harned, In Charge, Division of Cotton Insects, Washington, D. C.; N. O. Berry, Acting in Charge, Division of Mexican Fruit Fly Control, B.E.P.Q., Harlingen, Texas, and H. H. Shepard, Office of Materials and Facilities, U.S.D.A., Washington, D. C.

Another feature which added spice and variety to the program was the fact that no person presided over a session for a period of more than a couple of hours. In addition to the Chairman, the following persons presided: Vice-Chairman, F. S. Arant, Past Chairmen O. I. Snapp, Clay Lyle, E. W. Dunnam, R. C. Gaines, and J. T. Creighton.

Dr. John T. Creighton served as master of ceremonies at the annual banquet, which was held in the Georgian Room on the night of February 6. He performed in his usual easy-going, masterful way. The Past Chairmen of the Cotton States Branch were honored on this occasion, which was a celebration of the Silver Anniversary of the Branch. The current President and all past Presidents of the Parent Association who were present were also recognized and honored. These were: Roy E. Campbell, R. W. Harned, J. G. Sanders, F. C. Bishopp, and Clay Lyle.

One of the most interesting portions of the program took place on the last morning, which was devoted almost exclusively to discussions of new insecticides, with the following members of industry leading most of the discussions: Harry F. Dietz, E. I. DuPont De Nemours and Company; F. Ray Barron, Jr. and Bruce D. Gleissner, American Cyanamid Company; Fred W. Fletcher, Dow Chemical Company; and Donald R. Weber, Spraying Systems Company.

The local committee on arrangements, consisting of Hal C. Dilworth, Chairman, Harrold B. Jones and Robert C. Harnden, members, deserve much credit for the excellent manner in which they helped to make the meeting a success.

The following reports were submitted and unanimously approved except where otherwise stated.

Report of Secretary-Treasurer

The Secretary's report at Tampa showed a net gain of 11 active Branch members for the year 1949. The present report for the year 1950, shows a net loss of 88. This is a reduction from 438 in 1949 to 350 at the present time. This reduction was due to the formation of the Southwestern Branch which removed the States of Texas and Oklahoma from membership of the Cotton States Branch. The loss in membership was 124 from Texas and 20 from Oklahoma. During the year 1950 there was a gain in membership in every state in the Cotton States Branch except Tennessee. The gains in the various states ranged from 1 to 39, with Florida leading.

Financial Report

Although the Treasurer's books were audited at the Tampa meeting, no financial statement for that year was published in the Journal. Since no financial statement was published for 1949 and since the finances of the Branch are soon to be turned over to the newly-elected Secretary-Treasurer, a complete financial statement is given below covering the period from January 28, 1949 to the present writing, March 20, 1951.

Balance on hand January 28, 1949....		$ 356.26
Distributed as follows:		
Checking Account, Citizens National Bank, Waco, Texas.....	$229.63	
Savings Account, Atlanta National Bank, Atlanta, Ga.....	126.63	
Total.....	$356.26	

Receipts

Dues and contributions collected at Baton Rouge meeting	$182.78	
Reimbursement from Parent Association for expense of Baton Rouge meeting	150.66	
Dues collected February 3 to December 12, 1949	20.00	
Dues collected at Tampa meeting December 12–16, 1949	109.00	
Registration fee and contributions at Memphis meeting	207.00	
Interest accumulated July 1, 1948 to Jan. 1, 1951 on Savings Account, Atlanta National Bank, Atlanta, Ga.	3.81	
Total Receipts	$673.25	$ 673.25
Total bank accounts and receipts		$1,029.51

Disbursements

Expenses of Secretary-Treasurer in connection with attendance and business of Branch Meeting at Baton Rouge, January 31, February 1, 2, 1949	41.96	
Stamps, envelopes and mailing permit for circularizing membership and other expenses of Secretary-Treasurer in connection with attendance and business of Branch meeting at Tampa, December 1949	105.52	
Badges for Memphis Meeting	14.70	
Printing programs for Memphis meeting	55.67	
Stamps, envelopes and mailing permit for circularizing membership for Memphis meeting	40.51	
Telephone, telegraph, and other expenses of Secretary-Treasurer in connection with attendance and business of Branch meeting at Memphis	62.01	
Total Disbursements	$320.37	320.37
Balance on hand March 20, 1951		$ 709.14
Distributed as Follows:		
Checking Acsount, Citizens National Bank, Waco, Texas	578.70	
Savings Account, Atlanta National Bank, Atlanta, Ga.	130.44	
Total	$709.14	

Respectfully submitted
K. P. EWING

REPORT OF THE RESOLUTIONS COMMITTEE

1. Whereas, the members of the Cotton States Branch of the American Association of Economic Entomologists assembled in Memphis, Tennessee, February 5, 6, and 7, 1951 at their 25th annual meeting, have had a very interesting and instructive program on various entomological subjects, and

Whereas, it is realized that the success of the meeting was due to the efforts of many individuals, groups and agencies. Therefore, Be it Resolved: That we hereby express our special thanks and appreciation to the following:

(a) R. E. Campbell, President, American Association of Economic Entomologists, for his presence and participation in the meeting and for his informative and interesting address.
(b) Hal C. Dilworth, Chairman, and other members of the local arrangements committee who worked so hard and faithfully in providing equipment, entertainment, and otherwise making the meeting a success.
(c) Peabody Hotel for providing the excellent meeting room and other facilities.
(d) R. W. Harned and Anderson, Clayton and Company for the educational talk and film on cotton insests.
(e) N. O. Berry for the excellent film on the Citrus Black Fly.
(f) R. T. Yates, representing the National Agricultural Chemicals Association, for his timely and comprehensive address on the insecticide situation.
(g) F. C. Bishopp, H. H. Shepard and others who traveled long distances to be present and who made valuable contributions to the program by their willingness to be called upon at frequent intervals to answer questions from their storehouse of knowledge.
(h) J. W. Ingram, Chairman, and K. P. Ewing, Secretary, for their part in providing and arranging the program.

2. Whereas, since our last meeting we have lost from our ranks by death, F. F. Bondy, one of our loyal and faithful members. Therefore, Be it Resolved: That the Secretary be instructed to express the feeling of loss and sympathy of the Cotton States Branch members to the family of the deceased.

3. Whereas, the defense needs of the nation demand greatly increased production of food, feed, and fiber, and

Whereas, the control of insects that destroy crops and forests and carry diseases of man and livestock is a vital factor in securing maximum production, and

Whereas, National Legislation on pesticides has been recommended that in our judgement will if enacted seriously handicap the nation in its defense efforts. Therefore, Be it Resolved, that the Cotton States Branch of the A.A.E.E. express its grave concern over this situation, its desire to cooperate in presenting facts to Congress and its confidence in existing agencies and procedures in protecting the health and welfare of our people, and

4. Be it further Resolved, that this Branch oppose any reduction of inspection procedures from foreign countries to prevent the introduction of insects and other pests into this country.

C. H. ALDEN, *Chairman*
C. A. LINCOLN
W. W. STANLEY

REPORT OF THE EXECUTIVE COMMITTEE

This committee makes the following recommendations:

1. That the name of this Branch remain the same, namely, the Cotton States Branch.
2. That this Branch adopt the policy of meeting annually with the Association of Southern Agricultural Workers.
3. That this Branch have a Program Committee and a Public Relations Officer to work with the Program Committee—This officer to be selected by the Executive Committee.

Number 2 above was not approved by the membership. In lieu thereof, it was moved by John T. Creighton, seconded by Charles H. Alden, and unanimously voted that the Branch leave the place of the next meeting up to the Executive Committee.

REPORT OF THE AUDITING COMMITTEE

We, the Auditing Committee, have examined the books and accounts submitted by the Secretary-Treasurer for the year 1950. We find the books in order and properly balanced with vouchers and receipts attached.

We feel that the Branch should go on record as commending the Secretary for the excellent job he has done.

Respectfully submitted

R. C. GAINES, *Chairman* S. MARCOVITCH
W. A. DOUGLAS

REPORT OF THE NOMINATING COMMITTEE

Your Committee proposes the following names as officers of the Cotton States Branch, A.A.E.E., for the coming year:

Chairman—CHARLES H. ALDEN
Vice-Chairman—K. L. COCKERHAM
Secretary-Treasurer—L. C. MURPHREE

C. E. SMITH CLAY LYLE
O. I. SNAPP

MEMBERS AND GUESTS REGISTERED AT THE TWENTY-FIFTH ANNUAL MEETING, COTTON STATES BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, MEMPHIS, TENNESSEE, FEBRUARY 5, 6, AND 7, 1951

Alden, C. H., 432 State Capitol, Atlanta, Ga.
Alden, John C., Fort Valley, Ga.
Allison, F. E., 404 Tift Ave., Tifton, Ga.
Arant, F. S., Auburn, Ala.

Baeker, John S., Florence, S.C.
Baerman, G. D., 500 5th Ave., New York, N.Y.
Bailey, L. H., 3111 Lowerline, New Orleans, La.
Baker, W. A., Washington, D.C.
Barron, F. Ray, Jr., 30 Rockefeller Pl., N.Y.
Batson, W. N., 615 Yerger, Greenville, Miss.
Beckham, C. M., Experiment, Ga.
Becnel, I. J., 1804 American Bank Bldg., New Orleans, La.
Berley, J. A., Clemson, S.C.
Berry, N. O., Harlingen, Tex.
Bewick, L. F., Box 3816, Monroe, La.
Bickerton, J. M., 513 Esperson Bldg., Houston, Tex.
Bishopp, F. C., Washington 25, D.C.
Bixby, Arthur F., 1000 Widener Bldg., Phila., Pa.
Bone, R. S., Fayetteville, Ark.
Branch, C. B., Midland, Mich.
Broadus, E. P., 349 Oklahoma St., Jackson, Miss.
Brunn, Lynn K., Wilmington, Dela.
Budd, M. R., Wilmington, Dela.
Bussart, J. Everett, 215 W. Harrison, Wheaton, Ill.
Byrd, Felton, Box 1268, State College, Miss.

Calhoun, S. L., 312 W. 2nd., Leland, Miss.
Campbell, Roy E., 1208 E. Main St., Alhambra, Calif.
Cannon, Earl W., 238 Cross Rd., Oakland, Calif.
Chandler, S. C., 607 W. College St., Carbondale, Ill.
Chase, Ronald R., Wilmington, Dela.
Cochran, James H., Clemson, S.C.
Cockerham, K. L., Baton Rouge, La.
Collier, Barrett, 138 Taleiva St., Knoxville, Tenn.
Compton, C. C., Denver, Colo.
Condron, Carl H., Box 287, Uvalde, Tex.
Conner, Jim, Aberdeen, N.C.
Cook, Spencer E. Jr., Wilmington, Dela.
Creighton, John T., Gainesville, Fla.
Crigler, J. L., Box 120, Montgomery, Ala.
Crutchfield, Cecil M., Box 555, Auburndale, Fla.

Denning, D. G., 967 N. 10th, Laramie, Wyo.
Dennis, Norman M., 520 N. Juliette St., Manhattan, Kan.
Diaz, Joe, Denver, Colo.
Dietz, Harry F., Wilmington, Dela.
Dilworth, Hal C., P.O. Box 14, Memphis, Tenn.
Douglas, W. A., P.O. Box 1518, State College, Miss.
Dugas, A. L., Baton Rouge, La.
Dunavan, David, 116 N. Clemson Ave., Clemson, S.C.
Dunnam, E. W., 402 Feltus Blvd., Leland, Miss.
Dye, H. W., Middleport, N.Y.

Eden, W. G., Auburn, Ala.
Edgar, Coleman, 1210 Gulf States Bldg., Dallas, Tex.
Ellison, M. W., 500 Fifth Ave., New York, N.Y.
Ewing, K. P., P.O. Box 1218, Waco, Tex.

Farrar, M. D., 206 Long Hall, Clemson, S.C.
Fife, L. C., Florence, S.C.
Fletcher, Fred W., Midland, Mich.

Gaines, R. C., Tallulah, La.
Galloway, A. L., Richmond, Va.
Gibson, John W., 2541 Cashion, Oklahoma City, Okla.
Gleissner, Bruce D., 30 Rockefeller Pl., New York, N.Y.
Gratz, L. D., Gainesville, Fla.
Green, Henry B., State College, Miss.

Hamman, Robert E., Denver, Colo.
Hamner, A. L., State College, Miss.
Harnden, R. C., 707 Dermon Bldg., Memphis, Tenn.
Harned, R. W., Washington, D.C.
Harry, John B., 30 E. 42nd St., New York 17, N.Y.
Hartwig, Lester H., Union Springs, Ala.
Hetrick, L. A., Gainesville, Fla.
Hodge, Cecil R., Florence, S.C.

Ingram, J. W., P.O. Box 387, Houma, La.

Johnson, C. C., 117 Liberty St., New York, N.Y.
Johnson, Edward C., 517 1st St., Pompano Beach, Fla.
Johnson, Gerald H., 511 Shelby Ave., Memphis, Tenn.
Jones, M. P., Washington, D.C.

Kelsheimer, E. G., Box 678, Manatee Sta., Bradenton, Fla.
Kern, Curtis R., Wilmington, Dela.
Kinnear, Peter J., New York City, N.Y.

Lee, Horace W., 506 N. Cedar, Tallulah, La.
Lemmon, W. T., New York, N.Y.
Lincoln, Charles, Fayetteville, Ark.
Lowry, W. L., Stoneville, Miss.
Lucard, F. A., 1000 Widener Bldg., Philadelphia, Pa.
Lyle, Clay, State College, Miss.

Mailen, T. H., 1457 S. Hickory Ave., Bartlesville, Okla.
Marcovitch, S., Knoxville, Tenn.
Maughan, D. B., P.O. Box 1231, Orlando, Fla.
Mayeux, Herman S., Jacksonville, Fla.
McLeland, Harold H., 1832 Blake Blvd., Cedar Rapids, Iowa
Meek, Roy C., 1203 North 6th, Monroe, La.
Merrill, Gene, Box 412, Indianola, Miss.
Morgan, K. C., Box 1186, State College, Miss.

Nation, Hoyt. A., 567 Dumas Drive, Auburn, Ala.
Neal, James H., 134 Peachtree St., Atlanta, Ga.

Oliver, George W., 1010 E. Reno, Oklahoma City, Okla.

Patton, Don, 1407 Elmwood Ave., Nashville, Tenn.
Petrus, A., Box 3186, West Monroe, La.
Petty, Fred, Monroe, La.
Phillips, G. W., Greenwood, Miss.
Pierce, Henry F., Linden, N.J.
Piesbergen, N., 1700 S. Second St., St. Louis, Mo.
Pinckard, J. A., Denver, Colo.
Plant, E. K., 407 Johnston Bldg., Charlotte, N.C.
Purswell, H. D., 308½ Ivy Street, Atlanta, Ga.

Rapp, Frank, Wilmington, Dela.
Reed, John K., Clemson College, Clemson, S.C.
Reed, T. W., Field Laboratory, Haddonfold, N.J.
Reno, P. J., 1210 Gulf States Bldg., Dallas, Tex.
Rives, Quentin L., Forest City, Ark.
Roussel, John S., Baton Rouge, La.

Schroeder, Erwin F., Bryan, Tex.
Shepard, Harold H., Washington, D.C.
Shields, S. E., 346 Berry Field, Nashville, Tenn.
Smith, C. E., 2650 Zeeland Ave., Baton Rouge, La.
Smith, W. R., 203 Gerald St., Leland, Miss.
Snapp, Oliver I., Fort Valley, Ga.
Snipes, B. Thomas, 120 West 13th Ave., Denver, Colo.
Stanley, W. W., Knoxville, Tenn.
Stevens, John E., 50 West 50th St., Newfork 20, N.Y.
Strong, Rudolph G., L.S.U., Baton Rouge, La.

Tippit, J. T., 2209 Fredonia, Muskogee, Okla.
Toffaleti, James, Orlando, Fla.
Tomasek, H. F., 322 N. Sarah St., St. Louis, Mo.

Walker, Harry G., R.F.D. 1, Langborne, Pa.
Watson, J. Drake, Route 6, Box 11A, Montgomery, Ala.
Watts, J. G., Blackville, S.C.
Weber, Donald R., 3201 Randolph St., Bellwood, Ill.
White, J. F., Denver, Colo.
Whitfield, D. A., 1008 Fairview Ave., Greenville, Miss.
Wilson, Clifton Arlie, State College, Miss.
Wilson, E. H., 1801 Noman Bridge Rd., Montgomery, Ala.
Williams, Ralph E., 330 E. Grand Ave., Chicago, Ill.
Witman, E. D., 5th Ave. & Bellefield, Pittsburgh, Pa.
Woodbury, E. N., Wilmington, Dela.
Wylie, W. D., 231 Burl, Fayetteville, Ark.

Yates, Richard T., Wilmington, Dela.

PROCEEDINGS OF THE FIRST ANNUAL MEETING

SOUTHWESTERN BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Dallas, Texas, March 1–2, 1951

The first annual meeting of the Southwestern Branch of the American Association of Economic Entomologists was held in Dallas, Texas, March 1–2, 1951.

The meeting was called to order by Chairman H. G. Johnston. The invocation was given by K. P. Ewing. Following the invocation, Vice-Chairman D. E. Howell assumed the chair and presented Dr. H. G. Johnston for the annual address of the Chairman. The title of the address was "Trends in Insect Control."

The assembled group of 229 were pleased to hear greetings and comments from Roy E. Campbell, our National President. Thirty-five papers were presented, following a short preliminary business session in which committees were appointed.

An informal get-together was held on Wednesday night and a banquet Thursday evening followed by an entertainment.

Chairman Johnston called for the following reports:

TREASURER'S REPORT

	Credits	Debits
Transferred from Texas Entomological Society Account	$466.59	
Rubber stamp		$ 0.80
Announcements & Registration Forms		8.35
Postal card Announcements		4.65
250 Badges		28.13
Program Printing		39.35
Stamps		7.14
	$466.50	$ 88.42
Balance in Treasury February 26, 1951		378.17
	$466.59	$466.59

SHERMAN W. CLARK, *Secretary-Treasurer*

REPORT OF THE AUDITING COMMITTEE

We have examined the records and books of the Secretary-Treasurer and find them in order.

C. R. PARENCIA, *Chairman*
GEORGE P. WENE
DIAL F. MARTIN

The report was accepted by the membership.

REPORT OF THE COMMITTEE ON THE 1952 MEETING

After due consideration of telegrams, letters, and telephone calls from various cities in the State of Texas and after consultation with many individuals of the membership here assembled,

We, the undersigned Committee on Place of Next Meeting, recommend that the Second Annual Convention of this Branch be held in San Antonio, Texas.

K. P. EWING, *Chairman*
RALPH R. LLOYD, JR.
TED MCGREGOR

The report was accepted by the membership, and it was voted to hold the 1952 meeting in San Antonio, Texas.

REPORT OF THE NOMINATING COMMITTEE

The nominating committee nominates officers for 1951–52 as follows:

Chairman, R. C. BUSHLAND
Vice-Chairman, ANDREW J. CHAPMAN
Executive Committee, P. J. RENO

The membership unanimously approved the nominations.

REPORT OF THE COMMITTEE ON RESOLUTIONS

The following resolutions were adopted by the membership.

Resolution 1

Resolved that the Secretary express to the management of the Adolphus Hotel the thanks and sincere appreciation of the Southwestern Branch, American Association of Economic Entomologists, for the courtesies extended our organization.

Resolution 2

Resolved that the Secretary express to the Local Arrangements Committee the deep appreciation of each and every member of the Southwestern Branch for the splendid and successful plans which were so ably worked out for the comfort and entertainment provided the members and guests during this the First Annual Meeting of the Southwestern Branch, American Association of Economic Entomologists. This committee was composed of the following: P. J. Reno, Chairman; A. C. Gunter; C. A. King; J. M. Landrum; C. B. Spencer, Banquet Toastmaster.

Resolution 3

Be it resolved that the Southwestern Branch express its appreciation of the presence and participation in this our First Annual Meeting of the many visitors who have met with us and contributed so much to the success of these meetings.

Resolution 4

Be it resolved that the Secretary be authorized to write Mr. R. C. Bushland and express to him the sympathy of the organization in the recent death of his brother as the result of an automobile accident which prevented his presence in this First Annual Meeting of the Southwestern Branch of the American Association of Economic Entomologists.

Resolution 5

Resolved that this the Southwestern Branch by a rising vote express our appreciation to Dr. and Mrs. Roy Campbell for their presence at our First Annual Meeting.

Resolution 6

Resolved that the Secretary be authorized to write a letter of condolence to Mrs. P. N. Annand and to Mrs. S. A. Rohwer expressing the sympathy of this organization and the appreciation of the Branch and its individual members for the leadership and assistance to young entomologists over the years provided by Dr. Annand and Dr. Rohwer and that copies be placed in the permanent files of the Southwestern Branch.

Respectfully submitted,
L. F. CURL, *Chairman*
J. A. Cason
C. F. RAINWATER
Resolutions Committee

MEMBERS AND GUESTS REGISTERED

Abel, Carl O.
Abel, J. M.
Acock, Robert H.
Adams, J. F.
Akin, W. E., Jr.
Alexander, C. C.
Allen, William H.

Baerman, G. D.
Baker, Harold J.
Balzer, August
Barber, C. L.
Barrett, W. L., Jr.
Barton, Larry L.
Becnel, I. J.
Behse, O. C.
Best, W. N.
Bilsing, S. W.
Bixby, A. F.
Bone, Bob
Bourland, Don T.
Bowers, Harry A.
Brazeal, C. B.
Breazeale, Raymond
Broadus, Edward P.
Brown, W. B.
Brownell, John
Brundrett, H. M.
Brunton, J. G.
Brunn, Lynn K.
Burnside, W. H.
Bussart, J. E.

Calhoun, S. L.
Campbell, Roy E.
Cannon, Harold
Carpenter, Guy E.
Cason, J. A.
Chada, Harvey L.
Chadbourne, Dan S.
Chapman, A. J.
Chase, John S.
Clark, J. C.
Clark, Sherman W.
Compton, C. C.
Condron, Carl H.
Cook, Claude B.
Corley, Noad W.
Curl, L. H.

Dean, Herbert A.
Deer, James A.
De La Rosa, Jose G.
Denning, D. G.
Diaz, Joe
Dietz, Harry F.
Dilworth, Hil C.
Duckworth, Geo. C.
Dunnam, E. W.
Eads, W. J.
Easley, Tildon
Edgar, W. C.
Edwards, K. J.
Edwards, Rowland
Elliott, Carl L.
Elmer, Howard
Ewing, K. P.

Feistner, William E., Jr.
Fiero, George W.
Fletcher, Fred
Fletcher, Robert K.
Floyd, Jace P., Jr.
Foster, J. W.
Francis, W. B.
Freels, H. R.
Fuller, F. M., Jr.

Gaines, J. C., Jr.

Garner, C. F.
Garon, A. J., Jr.
Gibson, John F.
Gibson, John W.
Glick, Perry A.
Gordon, Jason O.
Gregg, Paul
Griffith, Richard D.
Gunter, Allen C.

Hallmark, K. D.
Hamman, Robert E.
Hammond, J. W.
Hanna, Ralph L.
Hardy, Wm. F.
Hare, Quinton A.
Harris, Lewis P.
Harvey, Harry C.
Haschke, Marvin M.
Heffernan, Tom
Hegi, Arthur E.
Hill, Carl, Jr.
Hillis, Aubrey M.
Hogg, G. F.
Hogue, Ralph S.
Houston, G. M.
Howell, D. E.
Howell, Jerome L.

Iahn, Stanley R.
Igo, Harry C.
Ivy, E. E.

Jarrett, Edward L.
Jarrett, Edward L., Jr.
Johnson, Charles H.
Johnson, Glen
Johnson, G. H.
Johnston, H. G.
Jones, R. W.
Jones, W. L., Jr.
Jordan, C. R.

Karman, M.
Kerley, B. J.
Kerley, R. V.
Kern, Curtis R.
Kennady, John W.
King, C. A., Jr.
King, Charles E.
Kirchhof, Gus
Kuiken, Kenneth

Laake, Ernest W.
Landrum, John M.
Lattimore, William B., Jr.
Lloyd, Edwin P.
Lloyd, Ralph R., Jr.
Lyne, T. B.

Magner, J. M.
Martin, C. E., Jr.
Martin, Dial F.
Martin, Leo A.
Maxwell, W. C.
McAlexander, D. J.
McBride, R. M.
McCauley, W. E.
McCulloch, George
McGregor, Ted
McGregor, W. S.
McKinney, D. H.
McKinney, D. R.
Meadows, C. M.
Merkl, Marvin E.
Miller, Dwight M.
Mistric, Walter J., Jr.
Moore, L. H.
Moreno, Tomas Leal
Morris, J. S.
Morris, Ralph L.

Naylor, John E.
Neel, Wm. W.
Neumayer, Eleanor M.

Noble, Lloyd W.

O'Neal, E. J.
Orr, Guy E.
Owen, B. L.

Parencia, C. R.
Parker, William B.
Paul, Rex
Peek, Carlton L.
Perlitz, W. J.
Petrus, A.
Pfrimmer, Theodore R.
Piesbergen, N.
Pospichal, Alfred T.

Rainwater, C. F.
Reno, P. J.
Retzloff, A. F.
Richmond, C. A.
Rider, F. L., Jr.
Riherd, Paul T.
Robertson, Oris T.
Rowland, Virgil
Rutledge, I. B.

Sanders, J. G.
Scales, A. L.
Schmitz, N. F.
Scholtz, Lenwood L.
Schroeder, E. F.
Selby, J. W.
Settle, H. H.
Shannon, Coy
Sharp, S. S.
Sharpless, Frank T.
Shiller, Ivan
Simonds, James M.
Skains, Marion R.
Smith, B. J.
Smith, Charles L.
Smith, H. Dean
Snipes, B. Thomas
Sparr, Bertram I.
Spencer, C. B.
Spicer, W. J.
Stanley, A. L.
Stiles, C. F.
Strong, Rudolph G.
Stroope, Don E.
Summers, George, Jr.
Swisher, E. M.

Taylor, Lester K.
Taylor, William A.
Teer, H. L.
Tennant, T. H.
Thomas, F. L.
Trimbos, C. A.
Torrey, John W.
Trolinger, Arthur
Turbeville, L. E.

Vaughn, Francis X.
Vitek, Rudolph C.

Wallace, D. K.
Walton, R. R.
Walters, H. A.
Watts, Carl N.
Weaver, Nevin
Weed, Alfred
Wells, R. W.
Wene, Geo. P.
Whipple, A. F.
White, A. N.
White, J. F.
Williams, P. L.
Williamson, Byron
Williamson, T. A.
Wipprecht, Read
Wood, W. R.
Woodbury, E. N.

Yates, Richard T.

PROCEEDINGS OF THE FIFTEENTH ANNUAL SPRING MEETING

GEORGIA ENTOMOLOGICAL SOCIETY

Abraham Baldwin College, Tifton, Georgia

March 9–10, 1951

The meeting was called to order at 1:30 P.M. on March 9, 1951, at Abraham Baldwin College, Tifton, Georgia, by President G. G. Rohwer. Mr. F. E. Allison, Chairman of the Committee on Local Arrangements, introduced Mr. George P. Donaldson, President of Abraham Baldwin College, who delivered an address of welcome. Mr. O. I. Snapp responded for the Society.

The President called for the minutes of the last meeting and the report of the Secretary-Treasurer.

REPORT OF THE SECRETARY-TREASURER, 1951

Instructions to the Secretary as recorded in the minutes of the 1950 meeting were carried out as directed.

Due largely to the good work of the Membership Committee, consisting of John C. Alden, Chmn., P. W. Fattig, C. C. Fancher, W. A. Legmen, and K. D. Quarterman, our active membership has risen from 39 to 66 in the past year. Over 100 copies of the minutes and of the various announcements have been sent out each time by the secretary to members and prospective members.

In response to a letter of inquiry by President Rohwer, the membership voted unanimously in favor of affiliation with the AAEE. Under date of January 11, 1951, Dr. E. N. Cory, Secretary of the AAEE, informed your secretary in the appended letter that the executive committee and the general membership of the AAEE had voted to accept the petition of the GES for affiliation.

The state of the treasury is as follows:

Credits	
On hand at date of last report (March 3, 1950)	$ 51.77
Dues received (7 for 1951, 57 for 1950)	64.00
TOTAL CREDITS	$115.77
Debits	
Stationery and mimeograph stencils	5.79
Stamps and postal cards	11.40
Rental fee for Legion Home, Fort Valley	5.00
TOTAL DEBITS	$ 22.19
Cash in National Bank of Athens	93.43
Petty Cash Fund	.15
TOTAL CASH ON HAND	$ 93.58

Mr. P. W. Fattig reported for the Ga. Insect Survey Committee a total of 13,505 species for Georgia. He is now assembling records on the Orthoptera of Georgia and requested the help of all members of the Society.

The President appointed the following committees:

Nominating:	C. H. ALDEN, K. D. QUARTERMAN, O. I. SNAPP
Resolutions:	W. E. BLASINGAME, F. R. BLACKWELL
Auditing:	G. R. SWANK, H. R. DODGE
Insect Survey:	P. W. FATTIG, E. E. BLASINGAME, C. M. BECKHAM

It was moved, seconded and approved that the Secretary should represent the Society in the presentation of matters to the Executive Committee of the American Association of Economic Entomologists or to the Association; that particularly desirable speakers from outside the State be invited to attend and present papers; that representatives in the State of the various industrial organizations concerned with entomology be invited to affiliate; that various interested entomologists from surrounding States be invited to attend the meetings and become members.

President Rohwer then read a telegram of best wishes from Vice-President Tom Gunn, on duty with the U.S. Navy, Patuxent, Maryland.

During the 2-day meeting, 20 papers were presented. These dealt with the housefly, mosquitoes, sarcophagids, pests of stored grains and processed foods, peach and pecan insects, phony peach diseases, white-fringed beetle, Japanese beetle, sweet potato weevil, cerambycid beetles, transit inspection, bee inspection and certification, and a report of activities conducted in Savannah by the Division of Insects Affecting Man and Animals. Two moving pictures were shown, one on Fogging with DDT for the Control of Blackflies with the Bell Helicopter, the other the Anderson-Clayton Company reel on Cotton Insects.

On Friday evening, 76 persons (members and guests) attended a banquet presented by the California Spray Chemical Corporation, whose Southeastern representative, Mr. F. E. Allison, acted as toastmaster. Entertainment was provided by a vocal quartet and soloist from Abraham Baldwin College.

At the final business meeting, the report of the Auditing Committee endorsing the Treasurer's report was on motion approved.

The Resolutions Committee reported as follows:

Be it resolved that the Georgia Entomological Society hereby express its appreciation to Abraham Baldwin College and to President G. P. Donaldson for use of the institution's facilities in holding the annual meeting of the Society on March 9–10, 1951, and to President Donaldson for his cordial and delightful welcome address.

Be it further resolved that the Georgia Entomological Society hereby express its appreciation to the California Spray Chemical Corporation and to Mr. F. E. Allison for furnishing the fine banquet and excellent entertainment to members of the Society and their families on Friday evening, March 9, 1951.

And be it further resolved that a copy of these resolutions be sent to the foregoing as an expression of appreciation for the facilities and entertainment furnished to the Georgia Entomological Society during its Annual Meeting on March 9–10, 1951.

Be it resolved that acknowledgement be made of a telegram received from Vice-President Thomas Gunn, U.S. Navy, Jacksonville, Florida, expressing regret that unalterable circumstances prevented his attendance at the Annual Meeting of the Georgia Entomological Society on March 9–10, 1951.

Be it resolved that the Georgia Entomological Society express its thanks to President G. G. Rohwer and other officers of the Society and the local Arrangements Committee, consisting of F. E. Allison, Chmm., T. J. Ratcliffe, and P. M. Gilmer, for their untiring efforts, splendid leadership and services during the past year and for formulating a comprehensive program which has contributed materially to the fine attendance at the fifteenth annual meeting.

The report was on motion approved.

The Nominating Committee recommended the election of W. G. BRUCE, BEPQ, Savannah, for President, and W. F. TURNER, BEPQ, Fort Valley, for Vice-President. The Secretary was instructed on motion to cast a unanimous ballot for these officers.

Mr. O. I. Snapp then urged that all members of the Georgia Entomological Society should be affiliated with at least one of the national entomological organizations. He also suggested that the members be ready to propose at the next meeting some useful investment of the Society's funds.

The Secretary was on motion authorized to have Society letterheads printed and the Executive Committee was instructed (on motion) to arrange for holding the 1952 meetings in Savannah in early March.

President Bruce then appointed a Membership Committee consisting of O. I. SNAPP (*Chairman*), G. G. ROHWER, and J. J. PAUL.

Members and guests registered at the fifteenth Annual Meeting were as follows:

C. H. Alden
John C. Alden
F. E. Allison
F. R. Blackwell
W. E. Blasingame
Ira B. Brightwell
W. G. Bruce
J. H. Cline
R. V. Connin
G. W. R. Davidson
H. R. Dodge
R. N. Dopson
Thomas Duck, Jr.
W. J. Dunn
Minter DuPree
R. T. Eubanks
H. M. Faircloth
C. C. Fancher
P. W. Fattig
Orlin K. Fletcher
P. G. Geiger
Jack Girardeau
Harold B. Hayes
Julius P. Hollon
Carlton Howell
E. T. Jensen
Martin L. Johnson
Glenn KenKnight
Charles E. Kennedy
E. L. Kessler

D. W. LaHue	Max R. Osburn	John Ridley	W. E. Towson
H. O. Lund	Kenneth R. Parkinson	James H. Rigsby	J. A. Turner
D. B. Maughan	J. J. Paul	G. G. Rohwer	W. F. Turner
Bobby R. McDonald	T. C. Perry	O. I. Snapp	O. M. White
Martel McGee	Hershel N. Pollard	Garth Spitler	Laney C. Williams
Glenn E. Moore	K. D. Quarterman	N. R. Stein	N. W. Youngblood
L. G. Moultrie	T. J. Ratcliffe	G. R. Swank	

ENTOMOLOGICAL SOCIETY OF PENNSYLVANIA

The Twenty-Eighth Annual Meeting of the Entomological Society of Pennsylvania was held January 10, 1951 in Room 107, Bureau of Plant Industry, State Capitol, Harrisburg, Pennsylvania.

The following members were present:

Dr. A. B. Champlain	Mr. Harry B. Kirk
Dr. Dean Asquith	Mr. Lloyd E. Adams
Mr. E. M. Craighead	Mr. W. W. Clarke, Jr.
Mr. W. C. Wheatfield	Dr. T. L. Guyton
Mr. Arthur R. Jeffrey	Dr. B. F. Coons
Mr. J. O. Pepper	Mr. S. G. Gesell
Mr. Gerald C. Lettie	Dr. M. W. Eddy
Mr. George B. Sleesman	Dr. H. Menusan, Jr.
Mr. H. A. Strohecker	Mr. E. J. Udine
Mr. R. B. Troxel	Mr. G. B. Stichter

The application of Mr. Gerald C. Lettie was approved for membership.

A letter from Dr. Cory verifying the affiliation of the group with the American Association of Economic Entomologists was read and the officers of the Society were empowered to jointly appoint a representative to the meetings of the parent association when the need for a representative is indicated.

The following officers were elected to serve in 1951:

Mr. ARTHUR R. JEFFREY—President
Dr. JAMES COX—Vice President
Mr. E. J. UDINE—Secretary

A summer meeting was approved by the organiz-a tion.

Dr. W. E. Dove was guest speaker and gave an interesting talk on the piperonyl-pyrethrum and rotenone combinations and their use on foodstuffs.

Following Dr. Dove's talk, a panel discussion on insect and disease conditions in Pennsylvania brought out the following items of general interest:

a. Dr. Guyton reported that no gypsy moth had been found in Pennsylvania in recent surveys, indicating complete control of this pest in Pennsylvania.
b. Mr. Clarke and Mr. Kirk reported on a brood problem of bees and observations pointed to the tulip-poplar scale as the source of trouble.
c. Mr. Sleesman reported on three insects new to Pennsylvania:
   1. *Leipidosaphes* probably *pallida* Green—from Taxus
   2. *Homadaula albizziae* Clark—from Honey Locust
   3. *Lecaniodiaspis* sp—from Barberry
d. Mr. Pepper discussed "grey wall" or internal discoloration of tomatoes and questioned its transmission or cause by insects.

Meeting adjourned at 5:00 P.M.

E. J. UDINE
Secretary

Dr. Harold H. Shepard was transferred, effective October 1, 1950, from the Insecticide Division, Livestock Branch, Production and Marketing Administration, to the Office of Materials and Facilities, Production and Marketing Administration, to act as Staff Specialist directing those activities of this new office which relate to requirements for pesticide materials, including insecticides, fungicides, herbicides and rodenticides. The Office of Materials and Facilities has been organized under Mr. L. B. Taylor as Director to carry our responsibilities of the United States Department of Agriculture under the Defense Production Act of 1950 for determining requirements of materials and facilities necessary for food production and conservation and for acting as claimant for such materials and facilities.

Mr. Lawrence C. McAlister, Jr., employed since November 1945 by U. S. Industrial Chemicals, Inc., Baltimore, Maryland, was reinstated, effective November 27, 1950, in the United States Department of Agriculture to assist Dr. Shepard, with headquarters in Washington, D. C.

Mr. K. A. Haines, of the Division of Gypsy and Brown-tail Moth Control, BEPQ, who had charge of the technical unit and who assisted in the large airplane spraying operations in Pennsylvania and Massachusetts was transferred from Boston to Washington on December 1, 1950, where he will be first assistant to Mr. W. A. Baker, Leader of the Division of Cereal and Forage Insect Investigations. Many of the former duties of Mr. Haines will be assumed by Mr. W. G. Harding who will be transferred from New York to Boston and located in the office of the Conservation Department, 15 Ashbuton Place, Boston, Mass.

Mr. Ralph Holbrook of the Division of Gypsy and Brown-tail Moth Control, will leave for Europe after January 1, 1951 to organize and direct the collection of female gypsy moth pupae in Spain, Portugal, France, Italy and French Morocco. His headquarters, while in Europe, will be in Paris.

OFFICIAL ROSTER

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICERS FOR YEAR 1951

President—ROY E. CAMPBELL, Alhambra, Calif.
First Vice-President—CHARLES E. PALM, Ithaca, N. Y.
Secretary-Treasurer—ERNEST N. CORY, College Park, Md.

Vice-Presidents

ED. H. LITTOOY, San Francisco, California (Pacific Slope Branch)
J. W. INGRAM, Houma, Louisiana (Cotton States Branch)
FRANK H. LATHROP, Orono, Maine (Eastern Branch)
C. R. NEISWANDER, Wooster, Ohio (North-Central States Branch)
H. G. JOHNSTON, College Station, Texas (Southwestern Branch)
W. A. PRICE, Lexington, Kentucky (Section of Apiculture)
HOWARD B. PETTY, Urbana, Illinois (Section of Extension)
..... (Section of Plant Pest Control and Quarantine)
LEE H. TOWNSEND, Lexington, Kentucky (Section of Teaching)
CARL J. WEINMAN, Champaign, Illinois (Section on Insecticides)
E. F. KNIPLING, Washington, D. C. (Section on Medical Entomology)
ALFRED B. BAIRD, Ottawa, Ontario (Section of Biological Control)

Branch and Section Secretaries

LESLIE M. SMITH, Davis, California (Pacific Slope Branch)
K. P. EWING, Waco, Texas (Cotton States Branch)
BYRLEY F. DRIGGERS, New Brunswick, New Jersey (Eastern Branch)
JAMES W. APPLE, Madison, Wisconsin (North Central States Branch)
SHERMAN W. CLARK, Houston, Texas (Southwestern Branch)
H. S. DEAN, Washington, D. C. (Section of Plant Pest Control and Quarantine)
R. L. PARKER, Manhattan, Kansas (Section of Apiculture)
E. H. FISGER, Madison, Wisconsin (Section of Extension)
R. H. DAVIDSON, Columbus, Ohio (Section of Teaching)
J. E. BUSSART, Wheaton, Illinois (Section on Insecticides)
D. E. HOWELL, Stillwater, Oklahoma (Section on Medical Entomology)
ALVAH PETERSON, Columbus, Ohio (Section of Biological Control)

STANDING COMMITTEES

Executive Committee

ROY E. CAMPBELL, Alhambra, Calif., Chairman (*Ex officio*)

CHARLES E. PALM, Ithaca, N. Y.
C. P. CLAUSEN, Washington, D. C.
A. M. BOYCE, Riverside, Calif. (1951)
ERNEST N. CORY, College Park, Md. (*Ex officio*)
BEN A. PORTER, Washington, D. C.
L. M. PEAIRS, Morgantown, W. Va. (*Ex. officio*)
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JOURNAL OF ECONOMIC ENTOMOLOGY

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BOOK REVIEWS

THE NEARCTIC LEAFHOPPERS—A GENERIC CLASSIFICATION AND CHECK LIST by Paul Wilson Oman. Memoirs of the Entomological Society of Washington No. 3, Washington, D. C., 1949. 253 pp. with 44 Plates of Figures and 4 pp. of references. Price $7.00.

This book has long been promised to the specialists in the leafhopper group and is an excellent contribution to our knowledge of the Nearctic forms.

The introductory portion of this treatise on American leafhoppers contains a number of general discussions on previous work, classification, morphology, binomics, life histories, host plant relationships, those known to be plant disease vectors, parasites, geographic distribution, technics for study, terminology, definition of terms and bibliographic information.

The major portion of the volume is concerned with a phylogenetic treatment of the subfamilies and genera of the *Cicadellidae*. Following the introductory portion is a key for the separation of eighteen subfamilies. Each of these is treated in sequence with designations of tribes and keys to the genera of each tribe. Some 223 genera are treated, 54 of which are described as genotypes. In several groups subgenera are used to subdivide large groups into smaller units. A generic description is placed under each of the genus names and the species placed in each genus by the author are listed together with their respective synonyms and a bibliographic reference. The general type of connective in the male genital structures is stressed in the determination of generic status and generic differentiation. Using the linear and Y-shaped types of connective, the author divides the tribe *Deltocephalini*, the largest group of the *Deltocephalinae* into two almost equal groups. The first character in the key separating some 129 genera is based upon this connective characteristic. Generic keys of this type exclude the possibility of the identification of female specimens to a large degree. While specialists or those more adept in using keys to the leafhoppers might be able to avoid difficulties at this point, it is almost impossible for students to use keys of this type. Advanced students and many specialists will probably never completely agree upon the generic or subgeneric ranking of certain groups due to the difference in the degree of emphasis placed upon certain characteristics. It seems that in some cases genera have been described or have been maintained which are too similar to previously described genera. As an example, genera such as *Latalus*, *Errastunus* and *Quontus* are very closely related, and their genotypes are difficult to separate on the basis of external characters. In such cases the generic status is questionable. In most cases, however, the generic designations seem to be well founded.

In the use of wing venation characters, Dr. Oman has numbered the apical cells from the posterior margin instead of from the costal margin of the wing and used the cell numbers in this way in his keys. This is contrary to the work of other authors and the previous work of specialists on wing nomenclature who number the apical cells from the costal margin, and will be confusing to students who are confronted with two systems of numbering wing cells.

In spite of these criticisms the volume as a whole should be considered as an outstanding piece of work and a basis for future taxonomy and research. The generic arrangement is new and appears very good and the illustrations are excellent. The amount of study and research work necessary to bring this material together and organize it in such a complete manner is tremendous and has required years of diligent effort. Also, the author's knowledge of the subject matter of this group is excellent and he is to be congratulated upon the completion of this fine piece of work. It is especially valuable to the specialists in this field and will be used extensively by them and students of the leafhoppers throughout the world.

DWIGHT M. DELONG
Ohio State University

CONSERVATION OF NATURAL RESOURCES. Editor, Guy-Harold Smith. John Wiley & Sons, Inc., New York; Chapman & Hall, Limited, London. 552 pp., 1950. $6.00.

This book should be of interest to everyone who has the welfare of his community, nation, and of future generations at heart. The field of entomology is only briefly referred to in relation to Wildlife studies.

The term conservation as used in this book refers to the intelligent planned use of all the natural resources.

A brief history is given of the land policy of the United States and the rise of interest in more effective methods of land utilization.

The industrial progress of the United States is primarily attributed to the abundance of mineral deposits such as coal, oil, and iron ore. Other minerals are in scarce supply or in some cases are necessarily imported even for current consumption. The non-renewable nature of these natural resources makes it imperative that they be used intelligently.

Other natural resources can be classed as renewable. That is, they can be restored by proper planning and supervision. This has been well demonstrated in the case of forests, fisheries, and wild life.

Recreational resources are classed as a natural resource. The need is stressed of developing recreational areas on a local and national basis. This is especially urgent because of the increase in urban population.

Many questions are raised concerning the most important natural resource, Man. Are we spending enough on the individual's education? Is our educational system doing the job expected? Is there a tendency toward lowering the general intelligence level due to a lowered birth rate among the educated?

It is pointed out that an effective program for the use and conservation of the human and material resources of the United States will require intelligent planning, research, and the cooperation of all private and governmental agencies concerned.

COLLINS VEATCH

JOURNAL OF ECONOMIC ENTOMOLOGY
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Journal of Economic Entomology

The Publication Privilege has been the subject of considerable discussion and some controversy in recent months. Much of the criticism comes from persons who are not members of the Association and who have, for that reason been denied the privilege of publication of papers in our JOURNAL. More often than not this criticism comes from sponsors of papers than from the authors themselves and in such cases they are very bitter in their tone and take the stand that such a rule is unheard of in the whole realm of scientific publications. This is, of course, nonsense, as there are many scientific and literary magazines and journals which maintain the same rule.

Inasmuch as some of our members sometimes join in with the outsiders in criticizing this policy it seems to be in order to review briefly the situation and see exactly how much discrimination against the outsider actually exists.

Our Association, in its present form, was established primarily to provide, by cooperative action, a publication medium for the members of the association who, in those days, were sometimes unable to publish certain types of articles in the state and federal publications which were almost the only vehicles for purely economic articles. All costs of publication have been borne by the members. The subscription revenues from the JOURNAL have never, or not since the very early days, produced enough revenue to pay the costs of publication and have been supplemented by the use of the major portion of the membership fees.

Also, in the early days, and occasionally until a decade ago, not too much attention was paid to the matter of requiring membership in the Association as a condition for free publication in the JOURNAL. About a decade ago such a rule was passed and has been adhered to except in certain cases where the Publications Committee has approved occasional exceptions for what seem to be good and acceptable reasons. But such exceptions have not been considered as precedents which abrogate the rule and the intent of the rule is still maintained. Most members of the Association and most of our contributors from outside the Association have recognized the justice of the rule and have acquiesced in adherence to the rule.

Those who feel that the rule is not fully justified, both outsiders and members of the Association, may well consider what the situation actually is. Let us ignore, for this argument, the financial needs of the Association, and consider the matter of fundamental justice of the rule. Outsiders claim that they are denied a privilege which the members enjoy. What right they have to complain is not made plain. The question is, is their complaint true. And the answer is most definitely that it is not. The author who is not a member of the Association is offered exactly the same privilege which the member enjoys. The member can publish only if he pays the annual membership fee. The outsider is offered the privilege of becoming a member, without payment of any entrance fee, merely the dues for the year in which he becomes a member. The sum which he pays at that time is the same as that paid by all members for the same year. The new member is not required to wait for any probation period before he is allowed to publish. It is assumed that he has joined in good faith although there is nothing to keep him from dropping out at the end of the year after having contributed probably only five or ten per cent of the cost of having his paper published. Any outsider who understands this situation, and it is made clear to all outsiders who seek to publish, can be classed as nothing less than a chiseler and does not deserve the sympathy which some of our members tend to lavish upon him. Actually fewer than 10 per cent of our members publish in any one year. The costs of publication are borne mostly by the members who do not publish. This is the nature and extent of the alleged discrimination. Fairly well standardized ex-

ceptions cover the cases where the outsider is publishing in our journal rather than elsewhere because the interest in his work is greatest in the entomological field. Such exceptions are usually granted to men who are members of other professions which sometimes overlap our own but are of such nature that the usual training of the entomologist does not qualify him to investigate.

It is quite probable that some cases worthy of classification as exceptions have been overlooked or misunderstood and that the JOURNAL has refused some articles which should have been excepted. But these cases have been exceptional and based on lack of knowledge. They in no way affect the validity of the general policy.

ECTOPARASITES TAKEN FROM TEXAS GOATS

During the course of ectoparasite studies[1] being conducted in the vicinity of Uvalde, Texas, approximately 100 angora goats have been examined by C. W. Johnson, O. L. Walker and the writers. Of special interest are the tick records that have been made. One adult specimen of *Haemaphysalis leporis-palustris* was taken from a goat (Zavala County, August 15, 1950) and 6 adult specimens from 3 goats (Uvalde County, April 1, 1950). The goat appears to be a previously unrecorded host for the adult of this common rabbit tick. Bishopp and Trembley (1945, J. Parasit., 31, 1–54) report two lots of nymphs and larvae of this species from this host although the locality is not given. Other non-rabbit records are: 1 adult from a cow (Uvalde County, July 14, 1950) and 1 nymph from *Citellus mexicanus* (April 10, 1950, Uvalde County).

Two nymphal *Ixodes* removed from a goat (Uvalde County, May 11, 1950) were referred to Glen M. Kohls, Rocky Mountain Laboratory, for specific determination. He states that they "appear to be *Ixodes tovari*." This species was described by R. A. Cooley from "hares" taken in Nuevo Leon and Guanajuato, Mexico, and has not been recorded from the United States or from the goat. Nuevo Leon is immediately adjacent to the Texas Rio Grande Valley, separated only by the Rio Grande River.

Additional ticks taken were: 10 spinose ear ticks, *Otobius megnini*, from 8 goats and 16 American dog ticks, *Dermacentor variabilis*, from 15 goats (August 15, 1950, Zavala County). One animal was host to both species of ticks.

All of the animals examined were infested with the goat louse, *Linognathus africanus*. These lice agree closely with the illustration of this species given by Ferris (Mon. of Sucking Lice, V. Stanford Univ. Publ., 1932). Infestations of *Bovicola caprae* were less commonly noted than *Linognathus africanus*. One specimen of *B. caprae* was taken from a dog (March 13, 1950, Uvalde County).—R. B. Eads and B. G. Hightower, State Department of Health, Austin, Texas.

[1] Supported in part by a grant from the Division of Research Grants and Fellowships National Institute of Health, Public Health Service.

ECOLOGICAL INSECT SURVEY IN PENNSYLVANIA

The Ecological Insect Survey in Pennsylvania is now in its third season. Although emphasis has been placed on economic species, such as mosquitoes, black flies, corn borers, etc., the scope of the survey will be increased as the years advance and as more money becomes available. Student help has been carrying on the work during past summers but in June, 1949, Mr. George E. Ball, a graduate student of Cornell, will work on the project for three months at State College. The results of the survey will be published in various technical publications. A detailed account of the nature and plans for the survey may be obtained from Dr. S. W. Frost, State College, Pennsylvania.

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